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DIVISION OF WATERSHED MANAGEMENT RESEARCH

Semiannual Report

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

October 1956 - March 1957

FOR IN-SERVICE USE ONLY

SEMIANNUAL REPORT
Division of Watershed Management Research
October 1956 - March 1957

Washington Office

Major jobs undertaken or initiated during the past six months include: participation in preparing the 10-year research program; revision of work and line projects; development of a proposal for collecting and interpreting hydrologic data on national forests; initiation of a pilot program of soil mapping and classification on national forests; and functional inspections.

The 10-year research program statements have been distributed to the field and were discussed at the RF&D meeting. Preparation of the revised work and line project descriptions, and development of the proposal for hydrologic data collection were greatly facilitated by the services of George Craddock who was persuaded to come to the Washington Office on an extended detail for those purposes.

The path has now been cleared for the accelerated development of techniques and procedures for conducting a program of soil classification and mapping on national forests to provide badly needed additional basic information for sound resource management on these areas. The Staff has decided to locate this work during its developmental and pilot testing stages within the Division of Watershed Management Research. Pilot studies now underway in Regions 2 and 3 will be expedited, and plans are being prepared for initiating or intensifying similar surveys elsewhere in the West. The survey program, with John L. Retzer as project leader, is being developed and conducted in close cooperation with the National Cooperative Soil Survey of the SCS to insure conformity with national standards. Reports to be prepared by Retzer are now scheduled for publication by the SCS on two national forest areas in Colorado.

Other activities included preparation of new job descriptions in connection with the reclassification of research scientist positions in both the supervisory and nonsupervisory phases; advice and assistance to the Charles Lathrop Pack Forestry Foundation in connection with its newly initiated study and educational program on the forest and water resources of the Southwest (see W.O. Information Digest No. 38, May 1, 1957); assistance to Resources For The Future in connection with a study on the available knowledge on the relation of vegetation, soil, and climate to water yield.

Storey and Jack Wetzel (SCS) spent 6 weeks in India, during February and March, assisting in conducting a watershed management training center for Asia and the Far East. The center was jointly sponsored by FAO and the Government of India. Foresters, soil conservation technicians, and engineers from 9 countries attended the training session. Lectures, discussions, field trips, and field problems were utilized in the training program. Subject matter covered a wide range, including physical, economic, and sociologic aspects of watershed management.

(Over)

One of the things that showed up during the meeting was the difficulty that technicians from a number of these countries have in obtaining technical information from the U. S. Due to strict monetary controls in the several countries, it is impossible for technicians to subscribe to technical journals from this country. It was proposed at the training center that FAO undertake to assist in distributing publications of technical information in connection with watershed management.

Frank served as a delegate from the District of Columbia on a "Potomac River Committee" which held a 3-day meeting at Annapolis, Md., together with representatives of the Maryland Legislative Council and representatives of other states, to discuss needs of the Potomac River basin and how they might best be met. The final recommendations included provisions for watershed management and improvement, among other basic features.

Work Committee on Russian Scientific Translations

The rapidly growing interest in finding out more about what Russian scientists are doing in agriculture and related fields, including forestry, hydrology, soils, and watershed management, etc., and in deciding what kind of effort is needed to make available the large volumes of materials published in the Russian language has led to the establishment of a Departmental Work Committee on Russian Scientific Translations under the chairmanship of Charles E. Kellogg. The Forest Service delegation is chairmanned by A. C. Cline, and its other members are Frank, Fowells (FMR), Buck (FFR), and Mayer (FER). Other Department agencies represented include FAS, ARS, AMS, SCS, and of course the Library. Meetings have also been attended by a representative from the National Science Foundation which is quite keen on stimulating a stepped-up translation program. At the last meeting it was agreed that funds should be sought to initiate work along the following lines: (1) Translation of Russian abstract periodicals; (2) translation of current issues of entire selected scientific journals, such as "Pochvovedenie" (Pedology), and possibly also of some pertinent reports of the Russian Academy of Science and some outstanding textbooks; (3) translation of selected articles, reports, etc., depending on their interest for the research scientists of the Department.

Some translation work presently is going on, of course, but it is generally agreed that the scale is much too inadequate. How soon this work can be expanded and in what fields will depend on a number of factors including the initial budget we are able to obtain, the availability of translators, and of course the extent and earnestness of interest among scientists in wanting to know what is going on in Russian science.

Publications

Lull, Howard and Storey, Herbert C. - "Factors influencing streamflow from two watersheds in northeastern Pennsylvania," Jour. Forestry 55: 198-200. 1957.

Abstract

"Effect of Herbicides on Soil Microflora," by M. Z. Machavariani, Acad. of Science publication, Vol. 8, pp. 99-107, 1954. Published in Georgian with Russian résumé, D. A. Library catalog 64.9 Ak12, Translation No. 9605. Only Russian résumé has been translated (by R. Adelman).

Although this study concerns field crops, nevertheless its findings may interest watershed researchers because the herbicide, by affecting soil microorganisms, may in turn affect the water relations of the soil.

The investigation sought information on the effects of the herbicide "dinok"[1/] upon the activity of such diverse microflora as ammonifyers, denitrifiers, azotobacter, actinomycetes, and fungi. The data showed that dinok--usually applied to the soil to control weeds--stimulated the growth and development of the ammonifyers. In May, a treated test plot showed 100 times more individuals per gram of soil than did the untreated plot. In June, the difference was 10 times.

Dinok has a different effect upon nitrifying bacteria: At first it depresses their energy but subsequently their growth and development are increased. For example, 10 days after application the number of nitrifying bacteria was one-tenth that of the control plot, but later their activity sharply increased. Denitrifying bacteria, however, increase tenfold in activity as soon as the herbicide is applied.

Azotobacter at first showed no effect but subsequently their rate of development increased. Actinomycetes were reduced in activity. No effect whatever was noted on the growth or development of fungi.

"Our data prove that herbicides exert the same action on soil microflora as on higher plants." Some physiological groups increase their activity, some cease growing and developing, while some are not influenced at all. Dinok reacts differently (in a positive sense) upon different physiological groups. In some cases its effects are immediate; in others, a depressive action occurs followed later by a stimulating effect.

According to Dr. W. C. Shaw (Weeds Investigations Branch, Field Crops Research Division of ARS, Beltsville), this chemical, also designated as 3,5 dinitro ortho cresol, has a fairly common use. American studies on the effects of this chemical on soil organisms appear in the Weeds Journal (a quite recent publication--only two volumes thus far), and Dr. A. S. Crafts, Dept. of Botany, Univ. of California, Davis, Cal., has conducted such tests.

1/ Chemical Abstracts describes "Dinoc" (not Dinok) as a sodium derivative, O-cresol, 4,6, dinitro.

--Bernard Frank

Forest Management Research
Semiannual Progress Report on Watershed Management Studies
September 1956 - April 1957

General

This is the first contribution made to the semiannual progress report by the Alaska Forest Research Center. The Center does not have a division of watershed management, but our forest management studies include some work in watershed management. Our volume of work in this field will probably not permit a contribution each time the semiannual progress report goes to press.

Current Studies

The Alaska Forest Research Center began a program of research in 1949 to determine the effects of logging on the physical factors of salmon streams. The principal objective of the study is to determine whether logging by Forest Service standards results in damage to the spawning facilities of salmon streams, and, if so, what means should be taken to prevent it. Four streams, characteristic of small- to medium-size island streams found in Southeast Alaska, were selected in 1949 for long-term study. Calibration was begun on a fifth stream in 1956. These streams are all located in the Kasaan Bay area, Prince of Wales Island. No logging had been done on any of the study watersheds prior to calibration.

The study will be divided into two main parts: (1) collection of information on the type and extent of physical change which takes place in the streams and on the watersheds prior to logging, and (2) change during and following logging. Three of the study watersheds will be logged; two will remain unlogged, as controls. The factors being investigated include:

1. Precipitation and air temperature

2. Streamflow
   a. Characteristics
   b. Storm analysis
   c. Ratio of maximum to minimum stream discharge
   d. Ground-water depletion

3. Stream temperature
   a. Maximum fresh water temperature
   b. Minimum fresh water temperature
   c. Relationship between water temperature and other factors

4. Stream channel change
   a. Debris, windfalls, and log jams
   b. Pools and riffles
   c. Streambank cutting

5. Movement of fragmental debris in an intertidal spawning zone
    a. Depth of disturbance
    b. Volume of material moved

6. Sedimentation
    a. Suspended sediment
    b. Streambed siltation

Studies to obtain information on the effect of physical changes on the fresh water stages of the salmon life cycle were initiated in 1956 by the U. S. Fish and Wildlife Service and the Fisheries Research Institute of the University of Washington.

Publications

Publications by the Alaska Forest Research Center relating to watershed management are as follows:

"Effect of rainfall on stream flow in Southeast Alaska" by L. W. Zach, Alaska Forest Research Center Tech. Note 4, 3 pp. 1950.

"The relationship between precipitation and stream flow on a typical Southeast Alaska stream" by G. A. James, Alaska Forest Research Center Tech. Note 24, 3 pp. 1955.

"The physical effect of logging on salmon streams of Southeast Alaska" by G. A. James, Alaska Forest Research Center Sta. Paper No. 5, 49 pp. 1956.

"Watershed management and research on salmon streams of Southeast Alaska" by H. E. Andersen and G. A. James, Jour. Forestry 55(1):14-17. 1957.

Comments

Probably one of the most important aspects of the salmon stream study is the phase on stream siltation. Heavy stream siltation has been found by several investigators to cause severe mortality to salmon eggs and larvae. Our investigation of this factor includes taking suspended sediment samples, streambed gravel samples and "silt-trap" samples. The silt-trap method consists of burying large fruit juice cans, which have been filled with washed gravel and small rocks run through a half-inch separator screen, in the stream bottom with the top of the can slightly below the streambed surface. The cans are removed after one or two years and a separation made to determine the quantity of fine material -- sand, silt, and clay -- which has been deposited.

None of the above described methods have proven entirely satisfactory. Suspended sediment samples do not tell how much fine material remains in the stream to silt up the spawning nests. Streambed core samples are difficult to obtain because of the presence of large rocks, bedrock outcrops, and swift, deep water. The silt-trap method appears to be the best technique at the present time, but it, too, has several

weaknesses. The ideal device would be one which would permit extraction of a stratified core sample from the streambed to a depth of about 10 inches. New techniques of gravel sampling are being investigated.

We welcome any comments and discussion on this or any other phase of the study.

SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

October 1956 through April 1957

GENERAL

An Advisory Committee has been organized to help guide the watershed management research program on the San Dimas Experimental Forest. The committee is made up of fifteen key individuals representing the varied interests in watershed management in southern California. The group's first meeting will be April 25 and 26 at Tanbark.

Lowell Andrews of the San Dimas Research Center received a $250 incentive award January 24 for the development of three research instruments--the San Dimas Soil Sampler, a Streamflow Peak Indicator, and a Reversal Indicator to be used on water-stage recorders. These devices already have contributed substantially to the Station's watershed management research, and they will be of continuing value here and in other regions.

The new snow research program is well underway. Winter's late arrival permitted the establishment of instrumentation and a needed building, and we have been fortunate in filling all technical and non-technical positions.

The Edward A. Colman Memorial Fund was accepted for permanent administration by The Regents of the University of California. In its new status it will be known as the Colman Watershed Fellowship Fund, and its proceeds will sustain the Edward A. Colman Memorial Fellowship. A Board of Sponsors has been formed to take responsibility for increasing the present $3,292 nucleus to an amount sufficient to support an annual fellowship of $2,000 or more.

PERSONNEL

Frank J. Mathys, age 65, died February 7 at Sawtelle Veterans Administration Hospital. A military funeral was held at the Sawtelle Cemetery Chapel, February 12. Matty, a veteran of 22 years in the Forest Service and loved by all who knew him, had spent the past six years at the San Dimas Research Center in Glendora.

James H. Patric, recent graduate of Harvard Forest, joined the San Dimas staff on January 7, 1957.

J. H. Kelleher, who has served as laboratory assistant on the Cover Improvement and the Soil Movement studies in Los Angeles River Watershed, transferred to Region 5 Road Investigations and Materials Testing Laboratory at Arcadia, California.

Ruth Duff was reemployed as statistical clerk at the San Dimas Research Center.

Ray Rice, District Ranger on the Palomar District of the Cleveland National Forest transferred to our Snow Hydrology Section as forest hydrology project leader.

Tom Pagenhart transferred from the Hydrology Section of the Corps of Engineers in Sacramento to the Snow Hydrology Section.

Gil Clark, recently with the Plumas National Forest, has joined our snow group as assistant supervisor of the Central Sierra Snow Laboratory.

New student and special assistants in snow research are: Joenne Cannon, Allan West, Don Rodgers, Roy Thompson, Ted French, and Cal Beck. Carl Johannessen and Bob Wagle left to concentrate on getting their PhD's.

PUBLICATIONS

Manuscripts Published

"Uses of soil-vegetation survey information in watershed management," by P. B. Rowe and E. A. Colman. Soil Science Society of America Proceedings, 21(1): 112-114, Jan.-Feb. 1957.

Discussion of "Forest-Cover Effects on Snowpack Accumulation and Melt, Central Sierra Snow Laboratory," by J. E. Church and H. W. Anderson. Trans. Amer. Geophys. Union 38: 116, 1957.

"Suggestions for Revision of Terminology Dealing with Fire" by A. W. Sampson and Clark H. Gleason, Jour. Forestry 55(3): 219, March 1957. The authors suggest changes to make the terminology of burning more specific.

New Manuscripts

"Anti-freezing Hoods for V-Notch Weirs" by Carl Johannessen. Submitted as a Journal of Forestry Note and presented as a supplement to this report. A simple method to prevent or reduce ice forming on a V-Notch Weir.

"Snow on Forested Slopes" by H. W. Anderson and T. H. Pagenhart. Snow accumulation and melt at 31 Central Sierra Snow Laboratory snow courses are related to terrain, solar energy, and forest variables. Will be presented for publication in the Proceedings of the Western Snow Conference.

"Operation Wet-Blanket Gets Underway" by H. W. Anderson. Progress in the new snow program and plans for new studies are outlined. Abstract submitted to Trans. Amer. Geophys. Union.

"New Snow Studies in Central Sierra" by Arnold Court and K. J. Walsh. Plans for snow physics and basic meteorological studies are outlined and installations described. To be published in the Proceedings of the Western Snow Conference.

"Soil-Vegetation Survey of Central Sierra Snow Laboratory," by R. E. Nelson. Presents detailed maps of timber stands, soil, and vegetation of the four square mile Castle Creek Basin as a basis for hydrological studies. To be published as a California Forest and Range Experiment Station Note.

"Andrews Peak Streamflow Indicator," by L. A. Andrews. Describes an inexpensive device developed by Andrews to obtain peak flow information at gaging stations where streamflow is not recorded continuously. Will be submitted for publication in Engineering News Record.

An outline for a proposed handbook, "Watershed Management in Southern California," was prepared by Sinclair.

"Effect of Fire on Streamflow from Small Watersheds in the Sierra Nevada Foothills" is the title of a thesis by R. A. Merriam for the M. S. degree in Forestry at the University of California. The thesis comprises part of a proposed publication by Merriam and Hamilton on hydrologic effects of the Sycamore burn in the Big Creek experimental watersheds within the Kings River drainage. (See Current Research)

"Reconnaissance Methods of Measuring Erosion" by Clark H. Gleason. Describes four kinds of reference marks that can be easily established and used to measure soil erosion. Submitted to the Journal of Soil and Water Conservation.

"Watershed Management Considerations in Sanitation - Salvage Logging," by Walt Hopkins will be published as a Station Note. The watershed manager considers sanitation salvage beneficial when properly done.

"Watershed Management--An Annotated Bibliography of Erosion, Streamflow, and Water Yield Studies by the California Forest and Range Experiment Station" is in preparation by Clark H. Gleason.

CURRENT RESEARCH

San Dimas Experimental Forest

Rainfall

The era of low rainfall continues. Totaling the Tanbark Flat rainfall for the 1956-57 hydrologic year to April 1, we get 14.7 inches. Looking into the matter of averages we find that this seasonal total is 2.6 inches less than the average for the last ten years. Looking farther back into the "good old days"--the early years of the San Dimas Research Center--our seasonal rainfall to date averaged 29.8 inches. This makes us feel really dry. The only redeeming feature in this perusal of rainfall statistics is that spring rains in the last ten years have been somewhat heavier than in the first 14 years, averaging 3.1 inches now and 2.7 inches then. This amount and distribution of spring rainfall has helped vegetation growth, thus aiding in the rehabilitation of burned watersheds. Further, the lack of major storms during the winter season has kept flood and erosion damages to a minimum, but local water supplies have been seriously reduced.

Some marked effects of different kinds of plants on water yield and loss are indicated by a long-term lysimeter study on the San Dimas Experimental Forest in southern California. This installation consists of 26 large concrete lysimeters, each 6 feet in depth. All are filled with a uniform mixture of local soil. The surface of the soil and the bottom of each lysimeter is on a 5 percent slope. Provision is made to catch and measure surface runoff and seepage from each unit. Soil moisture at various depths in several of the lysimeters also is measured periodically with Colman electrical soil moisture instruments. These measurements make it possible to determine water movement into and through the soil as well as evaporative losses from the soil and plants growing in the lysimeters.

Surface runoff, and conversely infiltration, seepage, and evaporative loss were relatively uniform from all of the lysimeters while the soil in each was covered with an excelsior mulch during a preliminary settling period of three years. Similarly, uniform results were obtained from all but one of the lysimeters while these tanks were covered with an annual grass during the next five years. The remaining tank was kept bare.

The infiltration rate of the grass-covered lysimeters increased a small but significant amount during this period, while that of the bare one remained at the very low value which characterized all of the lysimeters during the preliminary, excelsior-surfaced period. The annual grass cover was replaced with pure stands of native shrubs and Coulter pine in 1946. Groups of two to five lysimeters were planted to each species. A mixture of native bunch grasses was established in two of the lysimeters in 1952. The tank that was kept bare during the preceding five years has been maintained free of vegetation.

Some important differences in the disposition of rainfall under several kinds of plants compared with bare soil are indicated in the following table. These results were obtained during the last four years when the average annual precipitation was 6.4 inches less than the 28-year mean of 27.1 inches.

Results to date from this long-term study indicate that (1) water yield from bare soil 6 feet in depth was greater than from soil in which vegetation was growing, but the yield was entirely surface runoff during a period of subnormal rainfall; (2) water yield from an equal depth of soil supporting a cover of grass was much less than the yield from bare soil but the grass increased infiltration and thus reduced surface runoff. Further, ground-water yield occurred even during years of subnormal rainfall because infiltration exceeded evaporative loss from the soil under the grass; (3) all of the water available to evapotranspiration in 6 feet of soil under the shrubs and pine was lost during each dry season.

Average Annual Rainfall Disposition

San Dimas Lysimeters
October 1, 1952 - September 30, 1956

Vegetation cover	Rainfall 1/	Surface runoff	Infiltration	Seepage	Evaporative loss 2/
	Inches depth				
Bare	20.7	13.0	7.7	0	7.1
Pine	20.7	5.6	15.1	0	15.1
Chamise	20.7	4.1	16.6	0	16.5
Grass	20.7	4.0	16.7	1.7	15.3
Buckwheat	20.7	3.5	17.2	0	17.2
Scrub Oak	20.7	3.3	17.4	0	17.5

1/ Annual rainfall ranged from 16.01 to 25.39 inches.

2/ Evaporative loss = rainfall -(runoff + seepage - increase, or + decrease, in soil moisture storage during period). Includes evaporation from soil, transpiration, and interception loss.

Big Creek Watersheds

Preliminary analyses of reactions of the Big Creek experimental watersheds to the Sycamore wildfire were presented in the quarterly report for July - September 1952. Merriam has further investigated the possible effect of the burn on streamflow peaks for a Masters thesis (see publications). Peak streamflow discharges were related to rainfall variables by developing an equation through multiple regression analysis. The dependent variable was net peak discharge, defined as the flow greater than groundwater flow for storms producing more than 0.10 inch rainfall. The independent variables used were (1) maximum hourly rainfall rate, (2) antecedent seasonal rainfall, (3) storm rainfall antecedent to the hour with the maximum hourly rainfall rate, and (4) the ratio of total storm rainfall to the number of antecedent days with less than 0.10 inch of rain.

The opportunity was present for any effects of the fire to become evident. The storms during the first post-fire years were similar to those during the pre-fire years 1936-37 and 1940-41 used in the analysis. The first post-fire storm on October 24, 1951 had a maximum hourly rainfall rate of 0.69 inches per hour, or slightly greater than the maximum rate of 0.66 inches per hour recorded during the pre-fire years. Peak discharges during the post-fire period, however, were similar to the peaks which would most probably have occurred if there had been no fire. No consistent differences or fire effects could be detected.

Streamflow yield for the first year after the fire was similar to the yield during the two pre-fire years with similar rainfall. Summer streamflow from the spring in watershed 4 was slightly less during the first year after the fire than during the summers following the two pre-fire years. The 1951 fire did not affect streamflow from the Big Creek watersheds, probably due to (1) the rapid regrowth of annual plants which is typical in the grass-woodland type dominant on the watersheds, (2) intensive grazing use prior to the fire at lower elevations most accessible to water, and (3) the light intensity of the fire.

Characteristics of streamflow and rainfall during three years with similar rainfall, Big Creek Watersheds.

Item	Before the burn		After the burn
	1936-37	1940-41	1951-52
Total rainfall	32.14	35.15	34.86
Total streamflow yield	10.34	8.09	10.11
Streamflow as percent of rainfall	32.2	23.0	29.0
Number of days with greater than 0.10 inch rain	47	56	46
Date of last day with rain greater than 0.10 inch	4/26	4/30	4/25
Date of end of streamflow	6/13	6/17	6/10

Los Angeles River Watershed

Debris Movement Study

Measurements of debris movements were continued on mountain slopes under old vegetative cover in the Los Angeles River Watershed. Nearly four years of data have been collected. The rate of movement continues to be greatest on steep slopes above rejuvenated stream channels which are undergoing a new geologic erosion cycle. Support of these slopes was removed when the stream channels were down cut by stream erosion following the last uplift. This has resulted in accelerated debris movement on the slopes in the form of debris slides. At one site in Brown Canyon of the Arroyo Seco, one of these slides suddenly became activated during the 1956 summer season. During June and July prior to this activation the dry flow of debris (soil and rock) averaged only 1/2 pound per day. This debris flow increased rapidly until it reached a peak of 447 pounds per day towards the end of the dry season in December. This accelerated movement stopped when light rains wet the soil in January. A total of 5 tons of debris was measured during the 5-month period August through December. This indicated an average rate of movement 25 times that of the 18 months previous to the active period.

From the above observations it appears that dry movements of unstable materials on these steep slopes may consist of alternating processes of build-up and reduction.

Snow Studies

Results of Studies

Phase 1. A tabulation has been made of the distribution of forests and openings as determined from aerial photos for five transects of the northern Sierra above 5,000 feet elevation. Distribution of opening sizes, ground vegetation or conditions in openings, forest density classes, slopes and aspects follow:

Openings			Forest Density		Conditions in openings		Slope		Azimuth	
Class	Size (Chains)	%	Class	%	Class	%	Class	%	Class	%
I	0-1	24	0-14	56	Brush	50	0-10	11	N	20
II	1-2	3	15-39	19	Grass-Herb	26	11-20	41	E	20
III	2-4	6	40-69	18	Rock-Ground	16	21-30	21	S	28
IV	4-8	6	70-100	7	Trees	3	31-40	17	W	32
V	> 8	41			Other	5	41-50	6		
							51-60	2		
							61-70	2		
Total		80		100		100		100		100

The inventory is being made to assure that important site situations of the Sierra are not left out in designing our studies. The prevelance of brush and large openings is indicative. It is expected also that the inventory will be useful in application of research results, pointing out the amount of area subject to various management techniques.

Phase 8. The wind direction during snowfall has been analyzed using data from 14 storms in 1947-48 season at the Central Sierra Snow Laboratory headquarters. Precipitation amounts during each hour of each storm were classified according to the prevailing wind direction and velocity during that hour. Wind data were obtained at 52 feet above the ground just above the forest canopy. South winds brought some 72 percent of the storm precipitation. No significant relation was found between size or duration of storm and wind speed. In individual storms wind speeds during precipitation varied from calm to 16 mph, and the weighted median speeds from 2 to 14 mph. The median wind speed during all storms was 6 mph. The study is being extended by means of mountain-top wind direction and speed measurements.

Plans for these additional studies are being prepared.

Phase 8.--Studies of Snow Physics. The objectives are to determine

(1) The heat components over a snow surface in forest and openings

(2) The wind effects on the physics of snow accumulation in forest and openings.

(3) The evaporation and condensation at snow surfaces in forest and openings

(4) The heat and moisture physics of snow patches, and

(5) Snowfall and snow "weathering" phenomena in predicting snow melt in forest and openings.

Phase 9. Basic Meteorology and Snow Measurements, Teakettle Experimental Watershed Area. Meteorological and snow evaporation measurements are being made by the Pacific Gas and Electric Company as part of cooperation with the snow research program.

Phase 10. Water Yield from Water Yielding Units of the Sierra. Amounts and timing of yields from parts of the Sierra are being determined by analysis of streamflow data from many watersheds and years.

Phase 11. Heat Equivalent and Snow in Openings and on Forested Slopes. Preliminary studies are under way in testing the use of heat sensitive paper (Thermofax) in evaluating heat income and outgo at experimental sites.

MEETINGS

November 26-27.--Conference on Sediment Problems in California, College of Engineering, University of California, Berkeley. Rowe presented a statement on "Some Erosion Problems in the Mountain Watersheds of Southern California."

December 7-8.--Semi-annual meeting and field trip of Southern California Section, Society of American Foresters. Attended by Hopkins, Sinclair, Rowe, Hamilton, Merriam, and Coleman. Hopkins discussed the effect of logging high risk trees on watershed management in panel discussion of "Sanitation Salvage Logging in Southern California."

January 15-17.--Six members of the snow staff described phases of the snow research program at the California Snow Survey Conference in Yosemite.

January 29.--Knoerr presented Central Sierra Snow Laboratory research program to the administrative staff of the Tahoe National Forest.

February 13.--Anderson described snow research program at a meeting of Pacific Southwest Interagency Subcommittee on Hydrology at Sacramento.

February 15.--Anderson gave paper "Operation Wet-Blanket Gets Under Way" at AGU meeting in Sacramento.

February 21.--Joint meeting of the San Dimas Service Club and the San Dimas Water Company. Sinclair told of progress in watershed management research on the San Dimas Experimental Forest.

March 12.--Wyckoff discussed Central Sierra snow research at a combined meeting of the Tahoe National Forest and Truckee Hospital staff in Truckee.

March 20.--Wyckoff discussed snow research at the meeting of the Truckee Lions Club.

April 3.--Hopkins addressed the Fresno Engineers Club on the topic, "Watershed Management Research in California's Snow Pack Zone."

COOPERATION

Soil Conservation Service, Portland, Oregon.--Mr. J. H. Dorroh of the Riverside office, was furnished streamflow and rainfall data for use in projected hydrologic analyses.

Los Angeles County Flood Control District.--Rainfall intensity data were given to E. W. Godfrey, Hydrographer for the District. Historical information about the Brand Park channel barrier project was assembled at the request of Val Lund, U.S. Forest Service, for use by the District's sedimentation survey.

Corps of Engineers, U.S. Army.--Robert S. Wiese, Assistant Chief, Hydrology and Reservoir Section, was given data on erosion rates for desert slopes of the San Bernardino Mountains for use in design of proposed flood control structures.

Division of Lands, River Basin Planning, Forest Service, Region 4.--Marvin J. Rosa was supplied data for use in connection with the small watershed program.

Angeles National Forest.--Los Angeles River Flood Control Project was loaned rain gages and given advice as to their location in the Cooks Canyon area. The Forest Supervisor's office was also given mean annual rainfall data for 13 gages at various elevations on the Angeles.

U.S. Weather Bureau, San Francisco.--Inventories of soil temperature data taken on the North Fork Experimental area, the San Dimas Experimental Forest, and the Devil Canyon Branch Station were prepared for Robert F. Dale, State Climatologist. The Weather Bureau is considering possible publication of these data.

Glendora Public Library.--An exhibit of San Dimas Research Center publications was arranged in the library's display case.

Valleydale School, Azusa, California.--An exhibit of weather instruments requested by Mr. Lampson, was prepared for display in the Seventh and Eighth grade classrooms.

State Water Pollution Control Board.--Hopkins, Anderson, Gleason, A. E. Wieslander (FS ret.), and Prof. Paul J. Zinke, spent February 7 in Santa Cruz County with Raymond Walsh, Executive Officer for the Board, reviewing logging operations in the Santa Cruz watershed.

University of California, School of Forestry.--Gleason assisted Prof. R.N. Colwell's class in air photo interpretation on a field trip March 30-31 to the Bull Creek Watershed, Humboldt County.

Forest Management Division.--Experimental forest logging will begin on the Yurok Redwood Experimental Forest late this year. It was noted that stream channels in this watershed show the occurrence of active erosion. It was decided that an appraisal of erosion conditions was necessary before cutting started. Gleason, accompanied by Forest Superintendent Boe, examined the experimental forest watersheds in January.

Santa Barbara County Weather Modification Project.--Santa Barbara County has entered into a cooperative agreement with North American Weather Consultants, University of California, and the California State Department of Water Resources in a weather modification test located in the Santa Ynez River drainage. The Los Padres National Forest and the California Station are assisting wherever possible to help make this a successful test. Four recording rain gages from San Dimas were made available to the Los Padres Forest, Hamilton advised the State Division of Water Resources' technicians on rain gage location in the mountains, and Court and Hopkins have attended three consultation meetings.

VISITORS

During the past six months there were 140 visitors to the San Dimas Research Center. Seventy of them came as student groups, and there were 14 from Australia, Chile, Formosa, France, Germany, Ghana, Israel, Iran, and New Zealand.

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HOW TO DO IT

Anti-Freezing Hoods for V-Notch Weirs

By C. L. Johannessen

Streamflow measured by weirs may become inaccurate if water freezes on the weir or freezes just below the weir so as to pile up and interfere with the flow. To retard or eliminate such freezing, aluminum foil lined plywood hoods have been designed and constructed for 90° V-notch weirs. Five such hoods were installed in December 1956 on weirs at the Teakettle Experimental Watersheds at elevations of about 6,700 feet in the Sierra National Forest, California.

The hood's purpose is to trap and return the heat radiated upward from the water as it approaches and crosses the weir. To be effective, the hood must be relatively close to the bottom of the weir's V-notch. Yet, it must be designed and installed in such a way as to be self-removing before the water can rise to the level at which the hood could interfere with the flow. A self-removing hood was designed. (Fig. 1)

The hood rests with its two stainless steel strips "A" on the edge of the V-notch, and is supported on two 6"long, 5/16" diameter, brass rods (not shown) which extend out behind the weir plate and fit loosely through the holes in "C". The stop "B" prevents the hood from sliding forward. The bottom of the hood is 12" above the V-notch.

Tests at the Hydraulic Laboratory of the University of California, Berkeley, showed that when the stream flow through the V-notch rose to a depth of 11", the force of the water on the splash-board pushed the weir hood off the weir. Thus, the hood was removed from the V-notch before it interfered with the stream flow through the weir.

To rescue the hood when it is removed by a high flow, a length of strong wire is attached to the hood and to a support at the side of the weir in such a way that the hood will be swung out of the main stream channel by the force of the water.

Results.--Preliminary tests during freezing weather early in 1957 indicated that the hoods were effective in preventing ice formation at the V-notch weirs. Although ice on the reservoirs was 4-1/2 to 8 inches this winter, the weirs remained free (when stream flow ranged from 0.01 to 0.45 c.f.s.). A quantitative test of the effectiveness of the hood was made on the night of January 17-18, 1957, when the minimum temperature dropped to 18°F. At a weir, with no hood, freezing that night caused a decrease of 38 percent in the unfrozen area above the weir. At a weir to which a hood had been added for the night, the unfrozen water area actually increased 6 percent. Thus, there was an overall effectiveness of 44 percent in maintaining ice-free water associated with the weir hood.

During early winter when flows increased, the splash board was effective. The high water pushed the hoods to one side and the flow was unobstructed. The hoods were replaced after the high water subsided.

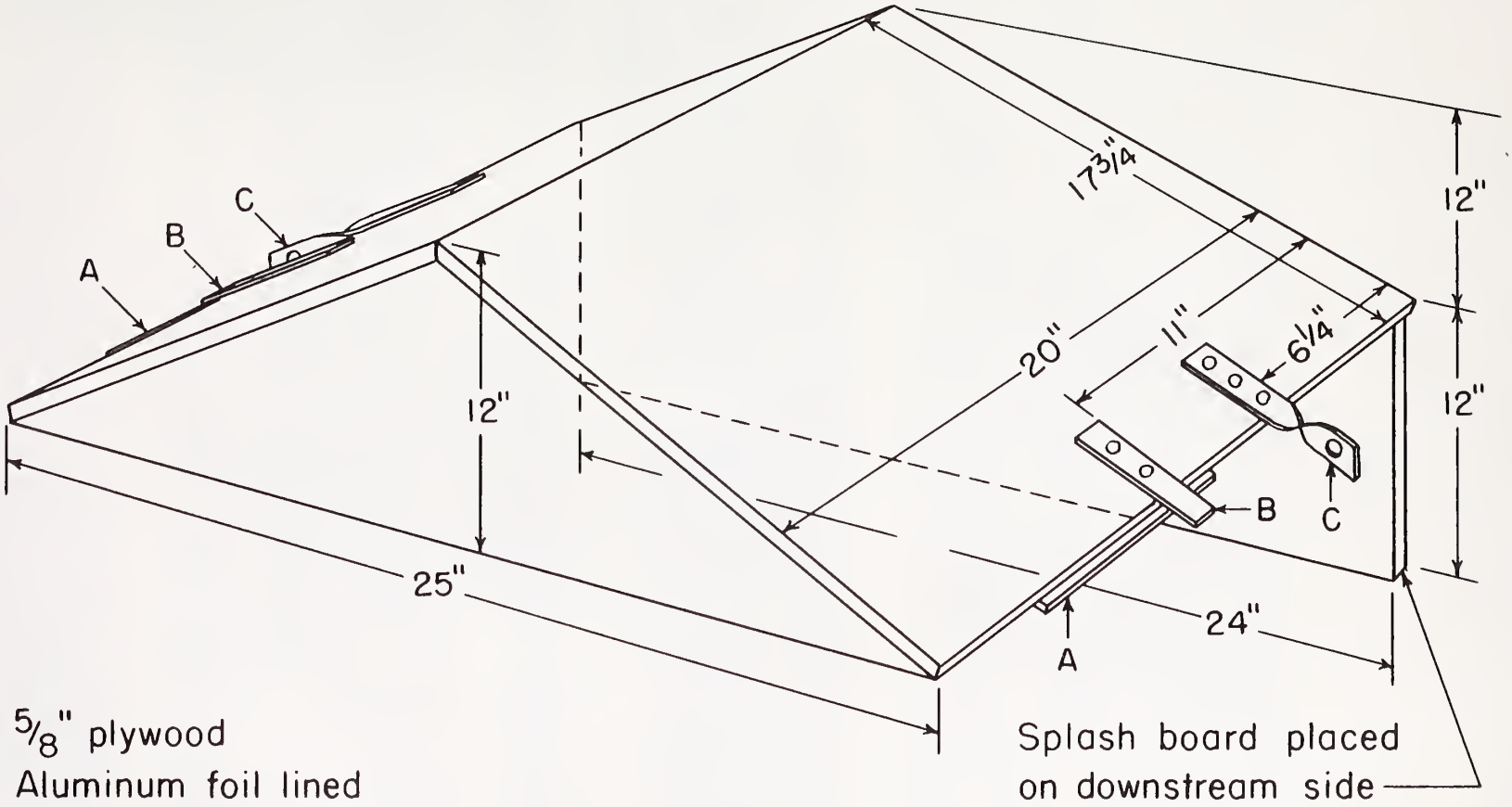

Fig. 1--Hood for 90° V-Notch Weir

SEMIANNUAL REPORT OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES FOREST EXPERIMENT STATION

October 1956 - March 31, 1957

General

Plans for an expanded Watershed Research Program at the Central States Station are being made in cooperation with ARS, Conservancy District, State Foresters, Universities and National Forest Administration. Strong interest in watershed research is shown by several agencies in Ohio. For example, the Muskingum Conservancy District is willing to make available land from the 40,000 acres under District management, and indicated it would furnish manpower and equipment to conduct studies under direction of our technicians. The State Forester of Ohio offered State land for cooperative watershed studies along with some financial help, such as for gaging stations. The Principal Engineer for the Conservancy District offered 3,800 acres under District Management as available for research.

High priority has been assigned to establishing a team of technical foresters at the Soil and Water Research Station of ARS at Coshocton, Ohio. Office space, laboratory equipment, five forest watersheds -- some with continuous records since 1939 -- and unanalyzed data from earlier forest studies are available. Under this arrangement, the Forest Service would assume leadership in research on forest land with ARS stressing the agricultural phases.

Effect on Annual Water Yields by Changing Type of Vegetation - Grass to Trees

Watershed No. 172, is a 44-acre watershed, at the Soil and Water Conservation Research Station, Coshocton, Ohio. For several years prior to installing the gaging station, the vegetative cover on 1/3 of the watershed was a stand of uneven age hardwoods with 2/3 of the area having a stand of broomsedge, poverty grass, and brush. The non-forested portion of the watershed was planted in 1938 with white, red, and pitch pine. Field notes state the crown closure was complete at the end of the 1945 growing season. Measurements that characterize the plantation are not available.

Methods developed by Kovner for estimating treatment effects with a log "t" time factor and adjusting rainfall to the mean precipitation for the watershed were used in the preliminary analysis of the rainfall and runoff data, (fig. 1). Water yield from watershed 172 did not show a significant time trend until after the crown had closed and for years after crown closure log "t" for the trend provided a better fit.

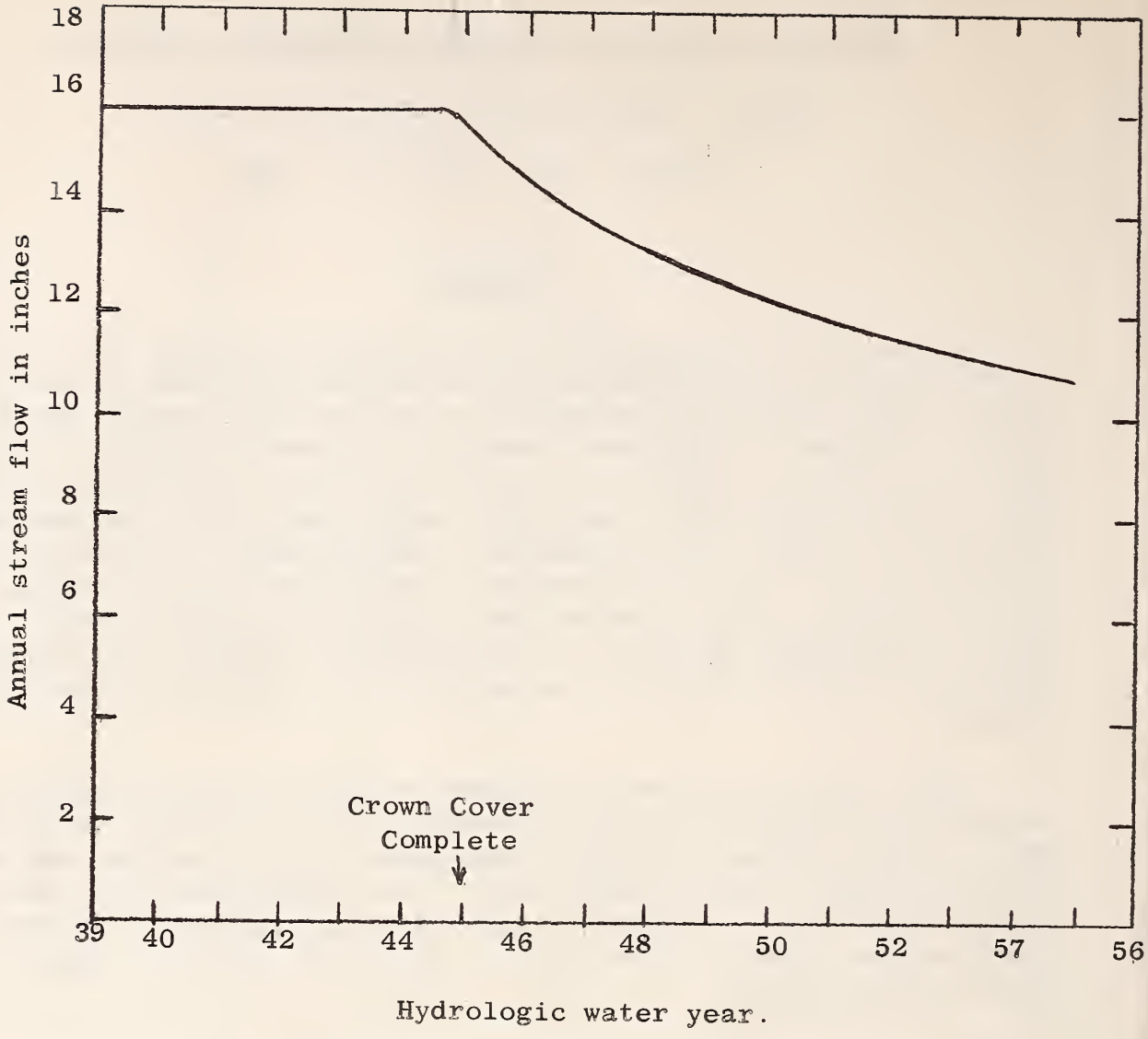

Fig. 1 -- Estimated changes in annual water yield as a pine plantation develops.

Additional analysis of these and other data from the forested watersheds at Coshocton are planned as soon as we have recruited personnel.

Cooperation - Soils Department, Missouri

Soils at the Sinkin Experimental Forest, Salem, Missouri, have a high stone content which may exceed 80 percent by volume. Soil moisture studies by Forest Management, Fire, and Range have encountered difficulties in determining the amount of water stored in the rock and soil mass. A cooperative aid project was initiated with the Soils Department, University of Missouri, for a basic study to test or develop methods for accurately measuring the amount of water present in extremely cherty forest soils. The first step in this study will be to develop a method for obtaining bulk density measurements when the chirt content exceeds 50 percent in the soil profile. George Carter, a Soil major at Missouri has started on the project and will use results from the first study as a Masters thesis.

Ames Research Center

The Corps of Engineers purchased entire farms in connection with the construction of Coralville Reservoir on the Iowa River. Land not needed for flood control will be available for transfer to other government and state agencies. This reservoir is adjacent to our Amana Experimental Forest, and Glen Deitchsman, Research Center Leader, is negotiating for land for forest and watershed management research. We are exploring possibilities for a cooperative watershed research program with the Corps that places emphasis on hydrologic changes and recovery rates in rehabilitating depleted Iowa land through forestry.

This year the Ames Center is scheduled to complete the problem analysis for their province which covers Iowa, a part of the driftless area in southwestern Wisconsin, and the loess bluff area long the Missouri River. Johnson has been spending time in Iowa getting familiar with watershed conditions and in analyzing watershed research needs.

Athens Research Center

by W. H. Carmean

General

During the past six months emphasis has been placed on compiling and analyzing data soil-site water runoff and soil moisture studies. Field work on soil-site studies has been completed and most of the soil samples gathered for current studies have been analyzed. A pressure membrane has been placed in operation in the soils laboratory.

Soil-site relations of upland oak forests - preliminary

Field data for this study was taken in 96 one-fifth-acre plots established in well-stocked, even-aged, undisturbed stands of upland oak. Data gathered included: soil profile and topographic description; stand measurements including total age and total heights of 5 dominant and co-dominant trees of all tree species present on the plot; tally of understory woody and herbaceous plants, identification of soil series and soil type; and, samples from three soil horizons for laboratory analysis.

Following are results of a preliminary analysis of the relationship between oak site quality and soil types as commonly mapped by the Ohio Soil Survey. This analysis resulted from the cooperative study with the Ohio Soil Survey reported in the April - September, 1956 Semiannual Report.

Reference to table 1 shows that several soil types are only represented by a few plots, therefore, average site index values are not dependable. Furthermore, considerable range and variation of site exists in most of the soil types that do have an adequate number of plots. If an adequate number of plots are available for a soil type the average site index value is fairly dependable, therefore, this average value may be used if if a general average site index is to be related to existing soil maps. Table 2 is a summary table listing the soil types or soil type groups that have average site values precise enough for general use.

Table 1...Relation between soil types and the site index[1] of even-aged upland oak stands in southeastern Ohio.

Soil Type	Number of Plots	Average Site Index	Site index Range	Standard Deviation	Coefficient of Variation (%)	Standard Error of the Mean	Fiducial Limits .05 Probability
Muskingum loamy sand	2	53.5	42.65	16.3	30.4	11.5	0-200
Muskingum sandy loam	11	77.7	60-94	10.2	13.1	3.1	70.9-84.5
Muskingum loam	9	74.2	60-85	7.5	10.1	2.5	68.4-80.0
Muskingum silt loam	22	71.7	48-90	10.7	14.9	2.3	67.0-76.4
Muskingum silty clay loam	1	48	-	-	-	-	-
	45	72.4	42-94	11.5	15.9	1.7	69.0-75.8
Wellston sandy loam	2	83.0	82-84	1.4	1.7	1.0	70.3-95.7
Wellston loam	1	-	-	-	-	-	-
Wellston silt loam	12	70.6	62-79	5.0	7.1	1.4	67.4-73.8
	15	72.3	62-84	6.2	8.6	1.6	68.8-75.8
Zanesville silt loam	2	81.5	76-87	7.8	9.6	5.5	12 - 152
Rarden silt loam	11	62.0	45-75	9.4	15.1	2.8	55.7-68.3
Rarden silty clay loam	2	47.0	44-50	4.2	9.0	3.0	9-85
	13	59.7	44-75	10.3	17.3	2.9	53.5-65.9
Keene silt loam	2	67.0	64.70	4.2	6.3	3.0	29-105
Keene silty clay loam	1	-	-	-	-	-	-
Coolville silt loam	3	64.3	51-77	13.0	20.2	2.4	54.1-74.5
Coolville clay loam	1	58.0	-	-	-	-	-
	4	62.8	51-77	11.1	17.7	5.5	45.2-80.4
Upshur silt loam	7	65.3	54-75	7.6	11.6	2.9	58.3-72.3
Upshur silty clay loam	3	62.7	54-68	7.6	12.1	4.3	43.9-81.5
	10	64.5	54-75	7.2	11.2	2.3	59.3-69.7
Brooke clay loam	1	51.0	-	-	-	-	-
Wyatt silt loam	1	57.0	-	-	-	-	-
Pope silt loam	1	87.0	-	-	-	-	-
Unclassified silt loam	1	73.0	-	-	-	-	-

1/ Site index values estimated from site curves published by G.L. Schnur (U.S.D.A. Tech. Bul. 560, 1937).

Table 2...Average site index for certain common soil types of southeastern Ohio.

Soil Group	Number of Plots	Site Index			
		Average (Feet)	Range (Feet)	Standard Error of the Mean (Feet)	Fiducial Limits .05 Probability (Feet)
Muskingum sandy loams and loams	20	76	60-94	2.0	72-80
Muskingum silt loam	22	72	48-90	2.3	67-76
Muskingum soil series	45	72	42-94	1.7	69-76
Wellston loams and silt loams	13	71	62-79	1.3	68-74
Wellston soil series	15	72	62-84	1.6	69-76
Rarden silt loam	11	62	45-75	2.8	56-68
Rarden soil series	13	60	44-75	2.9	54-66
Upshur silt loam	7	65	54-75	2.9	58-72
Upshur soil series	10	65	54-75	2.3	59-70

Average site index values are sufficient for general use, however, a forester is more often interested in specific site values for a specific area of land. A wide range of site values for particular soil types is not acceptable because a forest manager desires to know where the good and poor site land is located. Even though Muskingum silt loam has a dependable average site of 72 the forester is still unable to distinguish site index 48 areas from site index 90 stands. The above tables show that the average site for many soil types is not significantly different from other soil types and that the variation of site within soil types is frequently greater than the variation between soil types.

Results of this preliminary analysis indicates that the mere identification of soil types is not sufficient for precise estimation of forest site quality in southeastern Ohio. A wide range of A horizon depths, stoniness, subsoil characteristics, and topographic conditions occur within eachof the identified soil types. The large variation in site quality shown above is apparently related to these unmapped variables. The next phase of statistical analysis will consist of multiple regression that relates tree height to stand age and to various measured independent variables of soil and topography. Results of this regression analysis can be used for the estimation of site quality using permanent features of soil and topography.

Surface water runoff from small plots - preliminary analysis

Water runoff troughs, 4 feet wide and 20 feet long, were installed in 1954 to measure the quantity of surface water runoff from an undisturbed oak forest, an oak stand on a poor ridge site that had become clear cut in

the fall of 1953, and abandoned agricultural land with broomsedge and poverty grass cover. Three troughs are in undistrubed forest, 6 on the clear cut plots, and 3 on abondoned agricultural land. Volumes of runoff are measured after each storm. Plans are to relate the area inches of surface runoff with quantity and intensity of rainfall, soil moisture, time since last rain, and time of year.

Table 3 lists the greatest quantity of surface water runoff for each cover condition that has been measured during an individual storm. Under conditions of this study only a very small percent of total storm precipitation appeared as runoff from undisturbed forest land. For the range of observed data runoff volumes on abandoned agricultural land aid much greater than from clear cut plots or undisturbed areas.

Table 3... Maximum measured surface water runoff.

	Cover Conditions		
	Undisturbed Oak Forest	Clearcut Oak Forest with Natural Regrowth	Abandoned Agricultural Land with broomsedge and Poverty Grass Cover
	Inches	Inches	Inches
Storm Precipitation	0.60	1.42	0.97
Storm Runoff	0.01	0.17	0.41
Percent Runoff	2	12	42

Table 4 shows that surface water runoff for undisturbed forest is not only small in amount, but also that almost all of the storms observed produced runoff in the negligible range of less than 0.004 area inches. For clearcut forest and abandoned land most of the runoff is also in the negligible range because most storms producing measurable runoff are the frequent storms having only a small amount of total precipitation. Occasional large storms do occur, however, that results in rather large amounts of surface runoff. Large amounts of runoff are most likely to occur on abandoned land.

Table 4...Percentage of storms producing surface water runoff.

Storm runoff (Area Inches	Undisturbed Forest Percent	Clearcut Forest Percent	Abandoned Land Percent
0 to .002	73	30	36
.0021 to .004	14	23	17
.0041 to .006	6	13	8
.0061 to .008	5	6	7
.0081 to .010	2	4	5
.0101 to .012	-	5	5
.0121 to .014	-	6	-
.0141 to .016	-	1.1	1.7
.0161 to .018	-	2.5	-
.0181 to .020	-	1.4	1.7
.0201 to .030	-	2.6	3.4
.0301 to .040	-	1.8	3.4
.0401 to .050	-	1.4	-
.0501 to .100	-	1.1	6.8
.101 to .200	-	1.1	5.0
.201 to .400	-	-	1.7

Berea Research Center

by W. H. Carmean

A major development at this center has been the start on negotiations with Berea College personnel for using the 6,000 acre school forest in our Watershed Management Research Program. The entire water supply for the college and city of Berea comes from the school forest. Sherman Whipple, a graduate forester is employed by Berea College to manage the forest property. The college is interested in placing the watershed under management to supply forest products for their college industries and to determine protection requirements that will insure the best delivery of high quality water.

Following th January floods in southeastern Kentucky, the Berea staff and Johnson made a reconnaissance of the problem area for determining watershed research needs. This year Research Center Leader Williamson plans to complete analysis of problems in his province which covers the eastern half of Kentucky.

Strip Mining Study on Cumberland National Forest

Following the 1955 decision prohibiting the Stearns Coal Company from strip mining for coal on the Cumberland National Forest, Region 7 initiated action on a watershed study for determining the effect of strip mining on water resources. Beaver Creek on the Cumberland Forest was selected as the study area. There are five Federal and 5 State agencies in Kentucky cooperating on this administrative study. The work plan states to "determine what quantitati on changes will be produced in the following variables by the introduction of strip mining in a watershed.

1. Rate of sediment production
2. Duration of sediment cycle
3. Water quality
4. Regimen of runoff, (yield and peak discharge)
5. Stream geometry
6. Fish population, species and food count.
7. Net sediment contribution to Cumberland Lake.

Information obtaine d from this study would be used to design reclamation measures so that the effect of strip mining could be held to a minimum, to provide data to improve strip mining regulations, to estimate size of sediment pool required in future reservoirs, to estimate increased costs of treating water supplies for industrial and domestic uses, to determine the effects on fish, and to test theories on stream geometry."

Helton Branch, a 530 acre forested watershed under National Forest ownership was selected as the undisturbed control. About two miles away is Cane Branch, a 550 acre watershed or which rim type strip mining was underway on private land. This watershed was selected as representing a treated drainage. Instrumentation was completed on these two watersheds by February 1956. During June 1956, strip mining stopped because the operator claimed they were losing money. Plans for this study

are not to undertake rehabilitation work on the stripped area but let it remain as it is.

Results from this administrative study and increased stripping operations in Station territory focus attention on the need to clarify our thinking on this watershed problem. There is need for initiating a research program on the effects of strip mining upon streamflow, water quality, and sedimentation. We are planning to devote more time to the watershed management aspects of the strip mining problem upon National Forest lands in Station territory.

Columbia Research Center

by Ronald Whipkey

General

The first six months were spent in formulating a program of study and research for Ronald Whipkey, the trainee at the Columbia Center.

The major task at this time is hydrologic orientation and problem analysis for the Missouri Ozark region. A work plan was written to cover a study of some of the hydrologic characteristics of small watersheds. Plans are being developed for further studies into specific phases of watershed management.

Current Studies

Three small drainages near Rolla, Missouri have been selected for a study into precipitation-runoff relationships on Ozark small watersheds. The streams have been gaged by the U. S. Geological Survey since 1948; runoff and precipitation records for the period 1948 through 1955 are available. These will be studied for total yields, yield breakdowns and stormflow characteristics.

Watershed "B" is 6.41 square miles in area and is approximately 40% forested and 60% cultivated and pastured. Watershed "C" is 14.0 square miles in area and is approximately 80% forested with the balance in cultivation and pasture. The forest is oak-hickory and the main agricultural crops are hay, wheat, oats and corn.

The study areas are located in the 40-45 inch rainfall belt; approximately one-half of the annual precipitation occurs during the growing season. The soils are generally thin with poor structure--in many cases they are underlain at 18 to 30 inches with a fragipan.

Figures 2 and 3 illustrate the annual precipitation-runoff relationships for the three watersheds for the calendar year period 1949 through 1954.

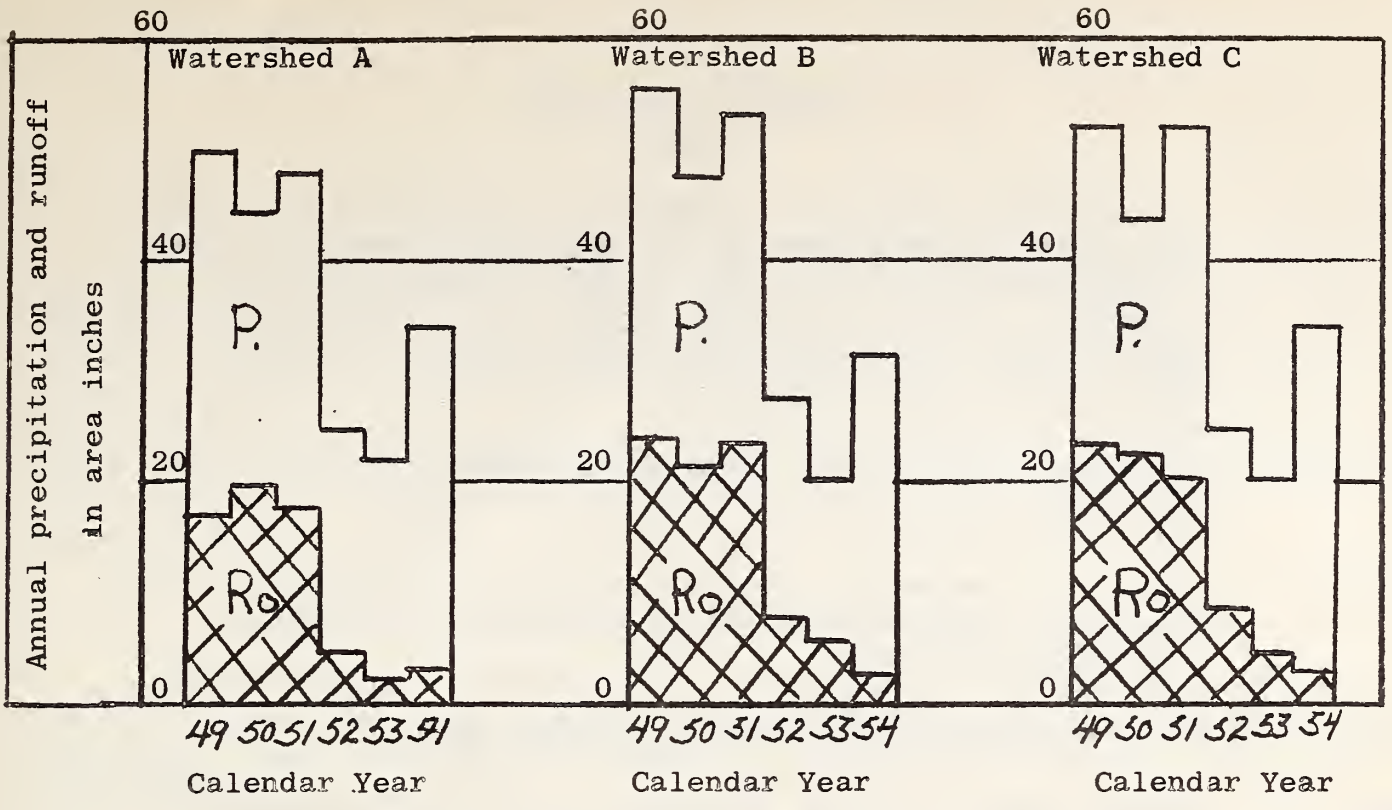

Fig. 2 - Annual precipitation and runoff for three small watersheds in the Missouri Ozarks, 1949-1954.

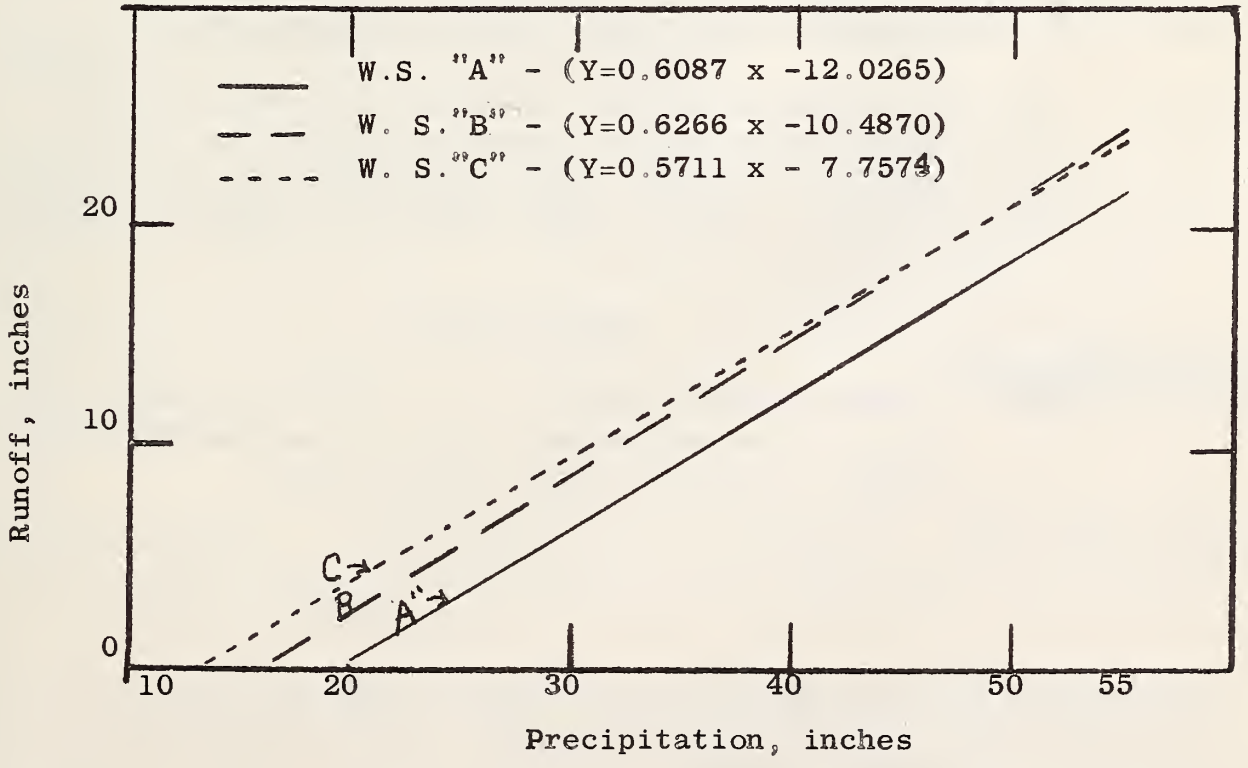

Fig. 3 - Relation of annual precipitation and runoff for three Ozark watersheds during 1949-1954.

MEETINGS AND TALKS

September 11. Johnson and Carmean were members of a watershed management panel at the annual meeting of the Central States Section, Society of American Foresters, held at Coshocton, Ohio, September 11, 1956. Johnson discussed watershed management research and Carmean discussed the role of forest soils in watershed management.

October 4-6. Johnspn was the Forest Service representative at the Annual Meeting and tour by Friends of The Land.

November 14. Johnson discussed the Coweeta watershed management research program at the Faculty seminar, Department of Forestry, Iowa State College.

December 5. Ohio Industrial Water Forum, Columbus, Ohio

December 7. Johnson gave a talk on "Partners in Watershed Management" at the Karkagne Club Meeting in Salem, Missouri.

January 16-17. Ohio Conference on the Importance of Natural Resources in the State's Expanding Economy.

January 21-22. Ohio Chapter Soil Conservation Society of America. Part of the Chapter Meeting was devoted to Watershed Development in Ohio

January 25. Annual Meeting of the Ohio Forestry Association.

March 29. The Forest Service Recruiting team with members from R-3, 4, 6, & 9 discussed federal employment and work with the Forest Service before the student body at Iowa State College. Johnson spoke briefly on "Opportunities In Forest Service Research.

PUBLICATIONS

Manuscripts Published

Carmean, W. H. 1956. Suggested modifications of the standard Douglas-fir site curves for certain soils in southwestern Washington. Forest Science 2(4):242-250.

COMMENTS

In the establishment of watershed treatments a question that arises is what stand characteristics should be used as the independent variable. For example, trees per acre, basal area, stand density index, cubic foot volume, board foot volume, crown canopy, leaf area and annual increments of growth, etc.. A density measurement factor by John E. Krajicek at the Ames Research Center suggest it may have application in some of our water yield studies. John would appreciate inquiries or correspondence on his density measurement factor before submitting a manuscript to Forest Science.

CROWN COMPETITION FACTOR, by John E. Krajicek

A method of density measurement, developed at the Ames Research Center, may be useful in watershed management research on forested areas. Preliminary tests indicate the method is independent of both site and stand age.

The measurement technique, called Crown Competition Factor, is based on the relationship of crown width to d.b.h. in open-grown trees, within a species. For each of several species tested, this relationship has been highly significant statistically.

In a truly open-grown tree, the base of the crown is quite circular. From crown width data for each d.b.h. class, the area of the base of the crown can be computed easily. This value then can be expressed as the percent of an acre, or the Maximum Area Requirement, for an open-grown tree of a specific d.b.h., within a single species.

The sum of the percent, or Maximum Area Requirement, for all trees on an acre is an expression of density, or Crown Competition Factor. If the value is less than 100, then theoretically no competition for crown space exists, with perfect distribution of trees. Any value in excess of 100 shows that competition is present for the average tree in the stand. The total percent, or Crown Competition Factor, can increase to a point of maximum stocking. This point is rather constant for a species, indicating that an increase in the size of one tree results in the mortality of another.

The Crown Competition Factor can be determined from tables similar to basal area tables, or through the use of an equation. In either method, the use of average diameter as a substitute for individual tree diameters can result in rather large errors.

To date, relationships between crown width and d.b.h. have been determined for black and red oak, white oak, hickory and Norway spruce. Limited data for other species indicate a strong relationship exists for all species.

The apparent success of the method is dependent entirely on selection of open-grown trees which have been free of competition from other trees at all times. Damaged, sheared, or pruned trees must be rejected also.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
October 1956-March 1957

DIVISION

Shortly after the first the first of the year, Craddock was detailed to the Chief's office for 2½ months to help the WMR Division while Storey was in India. One of the major tasks involved was the preparation of new Work and Line Project descriptions covering the proposed expansion of WMR activities in the next 5 years. He also worked with Cliff Davidson of Region 5 in preparing a plan for a proposed water resource evaluation program on the national forests.

Personnel

Harold F. Haupt transferred from the Boise Research Center to the Nevada Research Center at Reno, Nevada during the winter. He will head up the WMR work in that area.

Richard B. Marston started a Doctorate program at the Utah State University in January. Part of his program will include a cooperative and research project with the Utah State Agricultural Experiment Station on some aspects of consumptive water losses from aspen and mountain-brush sites.

Sevier Basin Water Yield Improvement Meeting

Prolonged drought in the southern part of the Station territory has made an already acute water supply problem critical. Chiefly affected are irrigated areas of central and southern Utah, predominantly those occurring in the Sevier River Basin. This situation provoked a joint meeting of southern Utah water users and several State and Federal agencies in February to consider means for improving water supplies in the drought-stricken areas.

The measures considered for increasing the amount of useable water available for irrigation included effects of phreatophytes on consumptive use; more efficient methods of storage, conveyance, and application of irrigation water; possibilities for further development of underground water resources; possible diversions of water from the Colorado River Basin; management of mountain watersheds for increased water yields; and the need for an economic analysis to determine the possibility of readjustments in the regional economy to activities not so dependent upon water.

The Station participated in this meeting by preparing a presentation on the possibilities for improvement of water yields from mountain watersheds in Sevier River Basin. This presentation consisted of a review of pertinent results of studies about water yield improvements throughout the country, a discussion of the limitations that probably exist for producing such increases in Sevier Basin, a summary of timber cutting and range management activities that have probably contributed to better water yields already, together with a projected resume of probable future timber cutting and range activities, and an indication of the kinds of research needed to develop and evaluate the management measures required for improving useable water yields. It is significant that, of five proposals for action concerning increased yields from watersheds coming out of this meeting, three involved recommendations for further research.

MISSOULA RESEARCH CENTER

Problem Analysis Completed for Northern Region Area of the Station

During the winter an analysis of watershed management problems and research needs in the Northern Region area was completed. Highlights of the analysis were summarized in this year's annual report. The analysis presented recommendations for a proposed program at two levels. One is the minimum program needed to effectively initiate research in each of the three highest priority problem areas of the region. The other is a more modest program within the capabilities of current facilities.

This analysis is being reviewed now by the Station staff and the Regional Forester's staff at Missoula. Planned for this spring or early summer is a meeting with the Region to consider the proposals contained in the analysis and coming out of reviews in order to settle on a definite program of research and spell out the Station and Regional responsibilities for implementing it.

Preliminary Results from Priest River Snow Studies

During the period 1949 through 1952 the Flood Survey Division of the old Northern Rocky Mountain Station conducted some so-called advance studies on snow at Priest River Experimental Forest in Idaho. With cessation of the flood survey program in 1952, these data were left uncompiled and unanalyzed. During the winter they have been compiled and preliminary analysis has been made of the effects of elevation, aspect, and canopy density on maximum water equivalent accumulated in the snowpack and on maximum daily depletion of water in the snow mantle.

Indications are that where the white pine type is clear cut, as much as 8 inches more water from snow alone may have to be handled by the soil mantle than is the case in dense forest. It also appears that the daily depletion rate of water in clear-cut areas may be as much as .35 to .50 inch greater than in dense forest. The data are being further analyzed to determine other relations, including effects of elevation and aspect differences on snow accumulation and melting.

NEVADA RESEARCH CENTER

The first steps have been taken toward initiating research on watershed management problems in the Nevada Research Center area. These included Haupt's transfer to Reno, the letting of contracts for a Center office in Reno, and a preliminary look into the watershed problems.

How to minimize flood discharges and increase the timber and forage productivity of the Jeffrey pine and brushlands on the east slope of the Sierra Nevada appears to be the high priority research problem in the new Center area. Winter floods from rapid melting of deep snow and summer floods from torrential rains have increased in frequency and violence in recent years. Flood damages in the Reno area alone now average in excess of $1 million per year. Flood runoff is known to originate, in part, on lands below which major structural control is not feasible. The flood-source areas are known to be drastically depleted of forest, brush, herbaceous and litter cover by reason of past fires, clear cutting of timber, and overgrazing. These lands are contributing only a fraction of their potential timber, forage, and recreational value to the regional economy and appear to have lost much of their flood control storage capacity.

Haupt is now undertaking a more detailed analysis of the watershed management problems of the Center area as a basis for developing a specific research program. He will work closely with a range researcher who is to be assigned to the Center. He will also consult with the California Station personnel so as to avoid unnecessary duplication of research being conducted on the west slope of the Sierra Nevada Mountains.

BOISE RESEARCH CENTER

Logging Road Location Guide

Further progress was made toward developing a guide for locating logging roads on steeply sloping ponderosa pine lands in southwestern Idaho. Data for development of the guide were obtained from observations of the amount and location of erosion which occurred below logging roads on a recently logged area in the Boise National Forest.

The observations were made after the area had been subjected to unusually severe climatic conditions including an above-average snowpack and a hard spring season rain which occurred when the mantle was still wet from melted snow.

Values of seven roadway characteristics were related to the distance sediment moved downslope from the roadway embankments. Four variables were found to be highly related to sediment flow distance. These included : a retardation factor (RF), derived from the sediment flow distance divided by the total number of slope obstructions; cross-ditch interval squared $(Cdi)^2$; embankment slope length (Esl); and the product of the cross-ditch interval and road gradient (Cdi.Rg). A prediction equation was then developed in which sediment flow distance in feet (Sfd) was shown to increase with increases in the four variables as follows:

$$Sfd = 1.2871RF + .003\ (Cdi)^2 + 3.4918\ Esl + .0468\ Cdi.RG - 66.2395 \qquad (1)$$

The standard error of estimate was determined to be 46.6 feet and the equation indicates that variation in the roadway characteristic indexes explains 77 percent of the variations in sediment flow distance.

One of the variables, embankment slope length, cannot be measured at the time of road location. Two additional equations were derived in which measurable characteristics were found to be related to embankment slope length. These are:

$$Esl = .7636 + .0455\ Lss \times Rch \qquad (2)$$

and

$$Rch = .1239\ Uss + .0956\ Lss - .0015\ Uss.Lss + 1.3855 \qquad (3)$$

in which Rch = road cut height; Lss = Lower side slope; and Uss = upper side slope.

The slope factors Uss and Lss can be measured in the field and directly substituted in equations (3) and (2) for calculating road cut height and embankment slope, respectively. The latter value can then be used in the main formula (2).

These three formulae and the sediment flow distance can be used for determining the width of buffer strip which is needed below a roadway to protect stream channels or lower roads from erosion damage. The standard error of estimate of the main equation (1) provides a basis for adding a safety margin to the predicted sediment flow distances and the width of the lower buffer strip.

This approach to a road location guide provides for considerable flexibility in field application because several of the equation unknowns are subject to control. These include road gradient; cross-ditch

interval; and the retardation factor, which is susceptible of change by the use of logging slash or other waterflow and erosion control treatments. Modification of these factors permits considerable leeway for the road locator to widen or narrow the width of the buffer strip below the road as conditions require and still meet logging haul road standards and requirements for erosion control. Arrangements are being developed to try out these guides during the coming summer.

WASATCH RESEARCH CENTER

Evaporation

Records of evaporation from a free-water surface were obtained from two high-elevation locations on the Davis County Experimental watershed last summer and fall. One location was a west-facing slope in an opening of aspen forest near the head of Parrish Creek at an elevation of 8,280 feet. The other was on a north-facing slope in an opening of aspen forest in the Chicken Creek portion of Farmington watershed at an elevation of 7,650 feet. Measurements were also made of air temperature, water temperature, and wind velocity.

Evaporation from the Parrish location was about 11 percent greater than from the Chicken Creek location. Average daily evaporation rates during the summer season exceeded those during the fall by 48 percent at the Parrish location and by about 43 percent at the Chicken Creek location (table 1).

Table 1.--Evaporation from free-water surface at two locations on the Davis County Experimental Watershed, June 13-October 19, 1956

Periods of Record	Parrish		Chicken	
	Total	Av. daily	Total	Av. daily
	Inches		Inches	
June 13-Aug. 27	23.23	.309	20.17	.269
Aug. 31-Oct. 19	10.54	.210	9.49	.189
Total	33.77	.270	29.66	.237

Mean air temperature at the two stations was highly correlated. It was higher at the Parrish location than at Chicken Creek during most of the summer but this relation tended to be reversed in the fall.

Average air movement was 2.96 and 1.01 miles per hour at the Parrish and Chicken Creek locations, respectively.

Evaporation was found to be highly correlated with air temperature, though this element accounted for only about 11 percent of the variation in evaporation at the Parrish location and 16 percent at Chicken Creek.

Correlation of evaporation with mean wind velocity was not significant.

GREAT BASIN RESEARCH CENTER

Drought Over?

April 1 snow surveys showed the snow peak at the head of Ephraim Creek contained about 31 inches of water. Though this is less than the maximum of record measured in the winter of 1952, it is substantially above average and assures local water users a reasonably adequate water supply during the coming summer. A 10-inch increase in the water content of the snowpack occurred in March, a new record for that month. One storm in that month brought 36 inches of new snow. It is planned to use aerial photography as an aid in the study of this snowpack on the experimental watersheds in that area.

Pleasant Creek Watershed Evaluation Study

A progress report on the 1955 phase of the Mt. Pleasant watershed evaluation study was completed and submitted to the Soil Conservation Service and other cooperators. Bob Thompson, who completed the report while on temporary assignment, returned to Brigham Young University for graduate work toward an M.S. degree.

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report April 1957

GENERAL

We (that is the Watershed Management Research staff at Upper Darby, all one of us) spent most of the last 6 months programming. Programwise, to coin a term, we found ourselves in the following situations:

1. Working with Supervisor E. M. Bacon and staff assistant Paul Sundheimer setting up snow surveys in the Allegheny National Forest --aided no end by a spare snow tube and scale that Chuck Wellner from Intermountain sent us.

2. Flying over the Potomac River Basin with Al Snow and Pete Bond (Asst. State Forester of Maryland) looking for experimental watersheds.

3. Locating a weir site for a cooperative research program with Pennsylvania State College and the Pennsylvania Department of Forests and Waters.

4. Inspecting the Kingston and White Pine-Hardwood Centers (I barely passed).

5. Walking the Fernow's proposed road system on the watersheds and listening to Sid Weitzman extol the ivy-clad environs of the Lake State Station.

Meanwhile, back at the Centers:

KINGSTON RESEARCH CENTER

New Studies

Following the completion and review of the Kingston watershed management problem analysis, a conference was called on October 11 in Harrisburg, Pa. to discuss possible studies that might be initiated in the Kingston Research Center area. Those attending were: Secretary Maurice Goddard, Joe Ibberson, Clyde Pyle and Gene McNamara from the Pennsylvania Department of Forests and Waters; Dr. Bill Bramble, Dave Worley, and Dick Byrnes from the School of Forestry, The Pennsylvania State University; and Marquis, Lull, and Reigner from the Northeastern Forest Experiment Station. After a short discussion, a three-way cooperative project was developed for watershed studies in the State

College area. A series of watersheds will be gaged to determine the effects of forest management practices in oak forests on water yield and quality.

The oak type, which covers more area than any other type in Pennsylvania, has been neglected in watershed studies. The State, with its increasing water problems, requires information on management practices. The State College area is ideal for the project, lying within the oak type and with large areas of University Forest and State Forest lands on which to locate watersheds. In addition, the Forestry School is eager to help set up the watershed studies for use as an outdoor laboratory in student training.

Since the original conference, Reigner, McNamara, Worley and Byrnes have combed the area for good watershed areas. It was finally decided to accept a series of watersheds examined during the first visit. They are predominantly sandstone but each has a low shale hill near its weir site.

Most of one week in March was spent at Penn State picking out the weir location for the first watershed and creating a suitable weir design. Ken Reinhart, of the Mountain State Center, attended the conferences along with Worley, Byrnes, McNamara and Reigner.

The weir design finally agreed upon is rather unconventional. The streambanks are low and the gradient is gentle at the weir site, thus eliminating the classic V-notch weir which requires a deep pool. A low control such as the Trenton-type would not give the desired sensitivity at low flows. The tentative design calls for a sharp-crested notch consisting of a 90-degree V at the bottom, grading into a 120-degree for the second foot. The notch will be set low in the control. Above the notch, higher flows will be measured on a one-to-ten slope across a broad crested section. A rating curve will be developed by periodic current metering. The design will be essentially similar to the Columbus Deep-Notch, but should be easier to construct and maintain.

Watershed Calibration

The Dilldown Watershed calibration analysis has been continued. Working for monthly streamflow estimates we investigated and refined the weighting system to be applied to antecedent rainfall in the estimation of total watershed storage. Originally, we had used a straight-line recession as a basis for figuring weighted antecedent moisture conditions. Next a reciprocal recession was used with improved results. The reciprocal in this case was 1000/9 + number days. Thus, the immediately preceding day was given a weight of 1000/9 + 1 = 100; the second day 1000/9 + 2 = 91, etc. We tested the weighting system by including two independent variables, the precipitation for the immediately preceding day and the precipitation for the second preceding day. Both were significant and showed the weight for the first day too high and that for the next day was too low. As this indicated the reciprocal slope was

too steep, we next tried a logarithmic recession, as suggested by Linsley, Kohler, and Paulhus. The difference between the two systems was negligible, but the latter is a much more describable value.

Extending antecedent values into the past, we found improvement in the storage relationship up to 80 days. Beyond this point, weighting becomes very small and calculations increasingly tedious. The logarithmic recession for this period begins at 100 and ends at 4.

After arriving at a tentative end point in monthly streamflow estimates we applied the same parameters to seasonal estimates. Results were discouraging until we dug into the problem; then several new relationships appeared.

We discovered that antecedent effects of precipitation vary between the seasons. In winter, when storage levels are high, antecedent effects past 40 days are unimportant. But in the warm months, when storage values may be low, antecedent effects back to 80 days are important. Furthermore, we found that antecedent rainfall may be weighted on a straight line basis. Thus, for a 40-day antecedent period, rainfall on the last day is given a weight of 40, while rainfall on the first day of the period is given a weight of 1. In the 80-day period, the last day is given a weight of 80. This relationship has been well tested. The straight line weighting systems result in higher correlations than the logarithmic system; also the weighting period for the spring and fall months turned out to be 60 days.

Another improved relationship is the use of sums of daily temperatures rather than an exponential form of mean monthly temperature. First, we summed temperatures over 50°F, as suggested by the Russian, Budyko. The sums of the daily maximum temperatures over 50° are highly correlated with the mean monthly temperatures to the fourth power. We like the summation as it is more logical and easier to explain.

Completing seasonal analyses, we used the new parameters in the year-long monthly analysis. Variable antecedent effects were valid, but the temperature factor was found to be curvilinear. Further investigation showed that the summation of maximum and minimum temperatures over 30 degrees should be used. A better expression of evaporation capacity would be the summation of hourly temperatures over the base temperature.

As usual, there is a lag in temperature. The temperature for the previous month is averaged with the temperature for the last month of the period on a 35-65 ratio. The new parameters have given the best estimate of monthly runoff to date.

Scrub Oak Conversion

The root rake site preparation was completed at the end of November; 245 acres were treated. Planting is proceeding at a fast clip even though the weather has been even less cooperative than usual. First we had warm weather which allowed the nurseries to dig and ship trees before we had anticipated, then after the trees arrived, we were besieged by snow and heavy rain. Groundwater is now at a high level--it was rather low 10 days ago--and many of the root raked strips are under water.

Meetings

Reigner attended the Allegheny Section meeting at Baltimore in February.

MOUNTAIN STATE RESEARCH CENTER

Gaging was started November 1, 1956 on Watersheds No. 6 and No. 7. Cutoff walls for the weirs were constructed about a year ago. One recording and 5 standard rain gages were put in operation. These two watersheds, each about 60 acres in size, will be used after calibration to separate out the effects of road-building practices from timber-cutting practices.

Our primitive soils lab was decimated last fall when we had to return a drying oven and Toledo scales which were on loan. After many delays, we were able to replace these items and to install a hot water heater and a new sink. Though still a modest setup, we are now in pretty good shape.

During the quarter, considerable progress was made in separating out the stone from soil samples collected last summer. We are using a wet-sieving technique. The lab is looking less and less like a dirt-storage warehouse.

We have obtained a Nuclear Moisture Meter designed by Dr. van Bavel and others and manufactured by William B. Johnson and Associates. Plans have been developed for testing the outfit and preliminary tests have been made. The instrument measures moisture content on a volume basis, thus presenting the opportunity to determine amount of water present without determining soil bulk density or stone content. We are having trouble getting the instrument to work properly; we hope that with Dr. van Bavel's help we can get it to live up to advance billing.

We have had considerable discussion of possible ways to improve muddy streamflow by settling out or filtering out sediments. Our interest is sparked by the need to minimize the effect of our "poor practice" watersheds on the stream leaving the experimental area. Trials will be made to see what we can come up with. Helpful suggestions from any source will be appreciated. A chute has been built for testing methods; we're groping our way forward slowly in this field.

Analysis of data from 5 years of record on watersheds 1 through 5 was completed. A session was held on the Fernow Forest from March 25 to 29 to review plans for treating the gaged watersheds. The experts Director Marquis, Lane, Lull from Upper Darby, Weitzman from St. Paul, and Trimble from Laconia, along with local personnel, worked over the problems from top to bottom. A sound basis for going ahead should result.

Reinhart prepared a paper Calibration of five small forested watersheds for delivery April 30 at the AGU meeting in Washington, D. C.

Reinhart attended planning session at Penn State to consider weir construction and other problems in proposed cooperative research between Penn State, Pennsylvania Department of Forests and Waters, and the Northeastern Forest Experiment Station.

WHITE PINE-HARDWOOD RESEARCH CENTER

Problem Analysis and Working Plans

A problem analysis for watershed management research in the White Mountain area has been completed and submitted to the Director.

The following working plans have been prepared:

"Installation and operations of snow and frost stations on gaged watersheds."

"For a study of treatment effects on humus conditions on gaged watersheds."

"For evaluating the effects of watershed treatments on sediment discharge from gaged watersheds." Proposes measurement of both suspended sediment and bedload.

"For skid road seeding studies on the Hubbard Brook Experimental Forest." Proposes further studies based on the results of seedings made at Bartlett in 1955 and 1956. The following mixtures will be tested on triplicated plots:

1. Red top - 10 lbs.; creeping red fescue - 10 lbs.; bird's foot trefoil - 10 lbs.; orchard grass - 10 lbs.
2. Red top - 20 lbs.; orchard grass - 15 lbs.
3. Red top - 20 lbs.; creeping red fescue - 15 lbs.
4. Red top - 15 lbs.; creeping red fescue - 15 lbs.; bird's foot trefoil - 10 lbs.
5. Red top - 20 lbs; alta fescue - 15 lbs.

These mixtures will be seeded with the following amounts of lime and fertilizer on a per mile of road basis (equal to approximately 1 acre):

1. 600 lbs. 10-10-10 fertilizer and 1 ton lime.
2. 600 lbs. 10-10-10 fertilizer and $\frac{1}{2}$ ton lime.
3. 600 lbs. 10-10-10 fertilizer and no lime.
4. 300 lbs. 10-10-10 fertilizer and 1 ton lime.
5. 300 lbs. 10-10-10 fertilizer and $\frac{1}{2}$ ton lime.
6. 300 lbs. 10-10-10 fertilizer and no lime.
7. No fertilizer and 1 ton lime.

A manuscript on seeding results to date is being prepared for publication.

An agreement has been made with Duke University for a cooperative study of White Mountain landslides and their revegetation. Ed Flaccus, a New Hampshire man who is working toward a Ph. D. in Ecology at Duke, is making the study. Ed has already mapped on USGS quadrangle sheets most of the existing slides. From this study we hope to get at least partial answers to most of the following:

(1) The magnitude and nature of the problem involved as it concerns water supplies--both actual and potential.
(2) The causes of these slides--if possible.
(3) Identifiable conditions to be found in areas where slides are likely to occur so that this can be considered before designating municipal watersheds.
(4) Any leads as to the need for designed research, and if needed, what type.
(5) The pattern of slide revegetation.

Studies Initiated

A study is underway to determine if the color of tree bark has an effect on the rate of snowmelt around the trunks. A number of beech trees were chosen for the study; one-third were painted white to a height of about 6 feet; one-third were painted black; and one-third were left unpainted. The width of melt rings will be measured at the four cardinal directions and co-variance analysis will be used to eliminate the effect of tree diameter. Due to the scant snow cover it may not be possible to complete the study this year.

A study to determine the effect of soil freezing on infiltration rate has been started. Ring infiltrometer runs are being made on frozen and unfrozen ground in forest and open cover. "Concrete" and "granular" types of freezing are being tested. If the condition termed "honeycomb" frost can be found it will be tested. Data collected to date indicate that concrete frost under open land conditions is impervious, but under woodland conditions may in places permit infiltration through root holes, worm holes, or burrows.

Office Reports

Three office reports on current work have been recently completed and submitted to the Director:

"On seeding logging roads in New Hampshire to prevent erosion" by John C. Bjorkbom and George R. Trimble, Jr.

"On the reconnaissance soil survey of the Hubbard Brook Experimental Forest" by Robert S. Pierce. Based partly on this work a paper has been prepared for publication and is in the final stages of

review (we hope): "A soil survey for forest land: A method developed for use in rough mountain land in the northeast", by Lloyd Garland (SCS), Robert S. Pierce, and George R. Trimble, Jr.

"On design and construction of gaging Station No. 2" by Robert S. Pierce. Replete with photos and diagrams this paper describes details of construction of a V-notch weir and gage house suitable for gaging small streams in the White Mountains.

Hubbard Brook Experimental Forest

Weir #2, a 120°, 2-foot V-notch installation, went into operation at the beginning of the dormant season--October 16. Weir #1 has now been in operation over a year. We made a volumetric calibration on weir #1 this past summer. Bob Pierce, who master-minded the construction job this summer, is completing a report covering our weir building experiences to date.

Ray Lavigne, who has been in residence at the Experimental Forest for 9 months now, has been busy on office computations of past rainfall and runoff records as well as collecting current data. We are now operating 2 weirs, 1 weather station, 2 recording rain gages, 4 standard rain gages, and 4 snow and frost stations where numerous observations are made on snow conditions (depth and snow water content) and on soil freezing. Bob Pierce teams up with him every Monday for a ski and snowshoe circuit covering all the watershed installations.

Construction of the permanent road into the Hubbard Brook Experimental Forest began in October. This first section of road will be about two miles long. When the contractor stopped work late in December because of heavy snow and subzero weather, about half the job had been done. We estimate he will finish up in early June unless a late melt period delays him in getting started again next spring. We hope that bids will be let early next summer for a second section of road.

Consideration is being given to making nuclear waste disposal tests on the Hubbard Brook Experimental Forest. The effect of this material on soil and water will be a big problem when the atomic energy plants now envisioned for New England are an actuality. Howard Lull has made some preliminary contacts. An on-the-ground meeting is planned for June with Dr. Thomas of Harvard and Dr. Joe Lieberman of the AEC.

We have received a portion of the 10-foot contour map of the Hubbard Brook Experimental Forest which is being prepared in Washington by the Engineering Division of the USFS from aerial photos.

Meetings

February 7-8--Sartz attended the annual meeting of the Eastern Snow Conference in Syracuse, N. Y. He presented a paper entitled "Snow and frost measurements in a watershed management research program". This will be published as a Station Paper.

March 7-8--Trimble attended the SAF meeting (New England Section) in Boston.

Miscellaneous

A large group of Soil Conservation Service Soil Scientists employed throughout New England made a tour of the Hubbard Brook Experimental Forest in October.....Sartz, Pierce, Lavigne, and Trimble attended a course in concrete-making given in Laconia by the Portland Cement people.

PUBLICATIONS

The role of forest humus in watershed management in New England. G. R. Trimble, Jr. and Howard W. Lull. Northeastern Forest Exp. Sta. Paper 85, 34 pp., illus. 1956.

Factors influencing streamflow from two watersheds in northeastern Pennsylvania. Howard W. Lull and Herbert C. Storey. Jour. Forestry 55: 198-200. 1957.

Water yields from small forested watersheds. Sidney Weitzman and Kenneth G. Reinhart. Jour. Soil and Water Conserv. 12: 56-59. 1957.

New Hampshire guides for logging roads and skid trails. G. R. Trimble, K. E. Barraclough, T. F. Breon, and L. B. Sargent. Extension folder 35, Univ. of New Hampshire, 4 pp., illus. 1957.

Manuscripts submitted

Soil compaction on forest and range lands. Howard W. Lull.

Forest soil-moisture relations in the coastal plain sands of southern New Jersey. Howard W. Lull and John F. Axley.

How far from a stream should a logging road be located? G. R. Trimble, Jr. and R. S. Sartz.

Snow and frost measurements in a watershed management research program. R. S. Sartz.

Forests guard the Potomac. Howard W. Lull and Ralph W. Marquis.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Watershed Management Research
Semiannual Progress Report, October 1, 1956 - March 31, 1957

General

A big hurdle has been cleared in these parts. For the time being, at least, we have all our vacancies filled and by this coming June all hands will be "on deck." We will welcome the chance to make some progress and to tell others what we have done rather than what we plan to do.

Bernie Frank heard a lot about these big plans last fall when he spent three weeks on a general integrating inspection of the division. Weather in the Northwest during November is not conducive to field inspections, but that didn't stop Bernie.

Snow Research

We are doing a little and expect to do more. Present activities are confined to our Blue Mountain Research Center, but we will get into more of it in the Bull Run watershed and in the Mid-Columbia and Siskiyou-Cascade Research Centers.

We are running into a problem of instrumentation which appears to be fairly common. There is not a scale on the market really suitable for weighing snow samples. Seemingly the necessary requirements for accuracy and portability can be met in custom-built scales, but at outlandish cost. If any of the snow boys have a solution it will be a big help to learn about it.

Watershed Legislation

Last fall the Umpqua Basin Conservation Council created quite a stir in Oregon when they proposed some legislation to regulate logging practices that lead to erosion and channel disturbance. All chapters of the SAF, Columbia River Section, were asked to consider the proposal and suggest a policy statement for the Section. Considerable heat and a minimum of light were generated. Dunford sweated out several panel "discussions." Upshot of it all was a resolution adopted by the Columbia River Section calling for more watershed research, better representation of foresters on state water groups and increased education of loggers in matters pertaining to watershed protection.

Mid-Columbia Research Center

January 1957 completed the first year of watershed research activity in the Mid-Columbia Province. The program is evolving from the stage of reconnaissance to one of planning and writing. A rough draft of a project analysis of forest and forest-range soils research has been completed. After local review, certain phases were approved. The rest is being rewritten. Another major writing effort is the watershed portion of the Mid-Columbia area problem analysis which is also underway. Completion of these two major writings should lend direction to the watershed research program.

The search for a satisfactory experimental watershed area may prove fruitful yet. Negotiations are now underway for a cooperative agreement with the owner of private land within the chosen watershed. Successful completion of these negotiations will allow the start of major long-term studies. In the meantime, some short-term studies will be undertaken.

Revegetation of denuded and eroding areas is a major problem in the province. Often the sites are severe south exposures in low (15-20") rainfall country. A spring broadcast treatment of grass seed and fertilizers will be tried. It is hoped the stimulation of the fertilizer will produce a seedling strong enough to survive the summer drought. A study plan has also been completed for initial work in determining the soil properties of major parent material types.

In October, at the annual meeting of the Soil Science Society of America, Wooldridge presented a paper entitled, "Soil problems relating to natural resource management in central Washington." A brief of his paper will appear in a forthcoming issue of the Proceedings.

Willamette Research Center

In early March, Jack Rothacher became project leader of watershed management research in the Willamette Research Center. Jack came to us from the Umpqua National Forest where he was ranger of the Steamboat Ranger District. With his arrival, watershed research in the Willamette Province will receive the continuity and emphasis it has needed.

One of Jack's first jobs will be an analysis of watershed problems in the Province. He will also have a backlog of streamflow data to handle as well as a series of working plans for further studies. This summer he will make a complete ground plan for roads in one of the three small watersheds in the H.J. Andrews Experimental Forest. We hope to build these roads during the summer of 1958, prior to the introduction of a logging treatment.

During the winter we have completed a new residence at the Blue River Ranger Station site near the H.J. Andrews Experimental Forest. It has been a badly needed facility. The watershed program on the Experimental Forest will greatly benefit from the closer supervision which will result from housing a year-round officer close to the scene of operations.

Blue Mountain Research Center

The research program at Blue Mountain Center has been strengthened by the arrival of Norm Miner, who will be project leader for watershed research. Norm has just received his Master's degree from S.U.N.Y. at Syracuse, having done his graduate work under Hal Wilm. He wrote his thesis on "Watershed hydrology applied to two Adirondack streams." He is currently busy getting acquainted with the country and our research program.

The Wallowa-Whitman National Forest recently sold 37 million feet of timber on the Starkey Experimental Forest and Range. This opens up a promising field to establish studies on the impact of logging on watershed values of the Blue Mountains. We are looking forward to cooperating with the Wallowa-Whitman in making the Starkey sale a model of what good watershed management should be. On private land near Starkey Forest we have some convincing examples of how thoughtless logging can damage watershed values.

Snow Management in Lodgepole Pine

Last fall Dunford and Trappe located a stand of lodgepole pine suitable for the first block of our snow management studies. These plots will be measured for 3 or 4 years prior to treatment. Then different systems of small strip or circle clearcut patterns will be tried.

The lodgepole stand is fairly uniform, with trees averaging around 5 to 6 inches d.b.h. and 60 to 65 feet tall. Occasional large, old western larch, grand fir, Douglas-fir and ponderosa pine are scattered through the stand.

Twenty points are randomly located in each plot for snow sampling. This winter and spring, samples were taken every two weeks during the period of snow accumulation, every week during the initial melt period, and twice a week during very warm spells that reduced the snow pack rapidly. A snow course was also run in the open, adjacent to the plots.

Three rain gages are in use for each plot. One is permanently located in an opening adjacent to the plot. The other two are randomly located in the plot. This provides a total of 5 open gages for each block of 5 plots, and 10 within-plot gages. The catch of the within-plot gages is measured and the locations changed every two weeks. Precipitation will be maintained throughout the year.

This is the first intensive study of snow accumulation and melt for the Blue Mountain region. First-year measurements have yielded some interesting data. The winter of 1956-'57 started with cold weather preceding the snow. As a result the ground was frozen to a depth of more than a foot before the first snowfall. The snow pack increased until a mass of warm air moved in late in February, causing a rapid melt. Throughout March the weather vacillated from warm, sunny spells to cold days with heavy snowfall. Preliminary analysis of part of the available data indicates that at the peak of snow accumulation the snow under the lodgepole averaged 68 percent as deep as in the open. Water interception by the lodgepole canopy averaged about 29 percent.

We are looking for ways to improve our sampling procedure for this study and would appreciate any suggestions from the "snow sages." Currently we are considering stratifying half of the snow sample points on each plot in areas to be cut and the other half on uncut areas intervening between the cuts. If unlimited time were available for the winter measurements, intensive sampling might work pretty well by this system. Since winter access is a problem, however, each block of 5 plots must be measured in a day, including jeep and snowshoe travel time. This just about limits us to 20 snow samples per plot, 10 on cut and 10 on uncut areas. It is possible that single-point sampling will not provide as much information as some other system. Any better ideas?

More Snow

It being winter, our efforts have been largely concentrated on snow since last September. We have been running two snow courses on Starkey Forest in cooperation with the state snow survey program. Early snows last October prevented us from showing Bernie Frank some of the high watershed rehabilitation work now started in the Elkhorn Mountains. We hope to see him again soon and when we can show him more of our alpine and sub-alpine problem areas.

Siskiyou-Cascade Research Center

Personnel changes have dominated the picture in the Siskiyou-Cascade Center. Lloyd Hayes, center leader since the formation of this branch unit, has gone to the Rocky Mountains. Bill Hallin, the new leader arrived in February and is rapidly becoming acquainted with the complex problems of forest and watershed management.

Our watershed research position at the center has just recently been filled. Gene Herring, a graduate student at Michigan State will report in June.

Bull-Run Project

In this part of the country the beginning of the hydrologic year finds water at a low ebb, but the spirits of ski enthusiasts at a rising tide. Skiers from near and far converge on the Mt. Hood area for the privilege of seeing how long they can prolong the skiing season without broken bones, twisted tendons or deflated egos. During the months, December-February, 233,000 people visited Mt. Hood ski resorts, thereby proving that snow has intrinsic values above and beyond that of supplying communities with water.

Field work in the Bull Run area continued throughout this period, albeit at a minimum level. Precipitation and streamflow gages required monthly visits, even though these visits demanded trips of 14 miles on skis. Because of the hazards involved in making these trips alone, personnel from the Mt. Hood National Forest accompanied us, and received our thanks in return for their tired muscles and spirits.

The first of three trapezoidal flumes was completed in October. After completion, it appeared that a rather sizeable leak had developed. In our efforts to determine its location we resorted to use of fluorescein dye. A small quantity of this green dye was dissolved in a milk bottle full of water and the bottle held under water at several locations above and in the flume. The green color appeared at the "leak" regardless of the dye's source--even when the dye was introduced at the point at which water flows off the flume. The conclusion was that water flowing off the flume entered the rocks, flowed under the flume and reappeared on the side, thereby giving the impression that a leak existed under or within the cutoff wall.

Two articles have been prepared describing our activities in the Bull Run project. One of these, jointly authored by Bethlahmy and the Chief Engineer of Portland's Water Bureau, will be sent to the Journal of American Water Works Association. A second by Bethlahmy and Barr is being submitted to American Forests.

SEMIANNUAL REPORT -- OCTOBER 1956 THROUGH MARCH 1957
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

We don't know what newspapers you read but surely you've heard that there is a lot of interest in watershed management in these parts. Every man is a water expert. Continual exposure to the genuinely serious problems brought on by the prolonged (or is it perpetual) drought and to much loud and noisy conversation about real and imaginary aspects of watershed management brings forth the following discussion for which we hope to be forgiven.

Optimism was required to settle in the Great American Desert and optimism often paid off. How long optimism can conquer reality is a question that must be faced in the Rocky Mountain territory. Unfortunately, this region just doesn't have the water supplies the expansionists say it has. When an item is in short supply but high demand, prices usually strike some kind of a balance and eliminate wasteful and inefficient uses. This perhaps happens for water but slowly and never completely. The market has played little part in allotting water because:

1. Water is an extremely cheap raw material. Even at $40 per acre-foot it costs less than 3 cents a ton!

2. Society, as well as market economics, determines the uses of water. The needs of a nation may require an irrigation project that is not justified by the crops produced. Recreational demand may dictate that a stream continue to splash over mossy rocks rather than run through a pipe to farm or factory.

3. Western water laws developed when farming and mining were then and foreseeably the most important uses for water.

4. Wishful thinking has entered into almost every consideration of the water problem. Not so long ago the interstate compacts divided up more water than was in the streams. Right now the distillers, rainmakers, and watershed managers claim that there can be more water for all.

Perhaps this is old stuff and is at least partly true in all regions. If so, there are some lessons for all of you in developments in this territory.

Irrigation is the big water user. It is also a consumptive use. Somewhere between 50 and 90 percent of the water applied to the crop is transpired or evaporated. Irrigators were the first water users and have the prior water rights. Most of the crops grown are of moderate value; some are profitable only because of price supports. Agriculture has expanded far beyond dependable water supplies. Many areas have not had enough water for all farmlands since the 1920's.

Recently there has been a phenomenal growth in the population of the big municipalities. This growth is dependent primarily on military and government establishments and new industry. Agriculture was already supporting about all the people it could. It takes a lot of water to make green lawns, run disposals, and otherwise supply the new residential requirements. Also the new factories need water in their processes. More electricity is needed and that takes water whether steam or water turns the turbines.

Significantly, the old irrigation use and the new uses are downstream and often in another drainage area. For the time being, farmers and city dwellers are united in their demand for more water. It is simple to point out the great downstream values and to claim that because of the growth of "worthless brush and trees" streams grow smaller each year. It is opportune for some needing more grass to join in these claims. Also those with the new stock tanks or with wells sucking from the upstream valley aquifers eagerly join in attacking the worthless "brush" perhaps in hopes of diverting attention from their activities.

These alliances are obviously temporary but for the moment there is great unanimity in the claim that something must be done to send more water downstream. If some are working to use water more efficiently downstream or wondering how it can pay to irrigate 40 bushels of corn, or perhaps suggesting that green lawns in the desert are wasteful, they are keeping mighty quiet about it. There is no doubt but what water will have to be used more efficiently in the future. Yet--and this is where watershed researchers are not blameless-- all of the present effort is an attempt to postpone the time of more efficient water use. It has become a cliche to emphasize that a watershed must be considered as a whole, not in separate parts. Do we practice what we preach?
Are we becoming obsessed with the idea of squeezing more water from watersheds and forgetting that we should strive for efficient and economical use? Are we too ready to lend encouragement to present downstream users? In the future, will a shady grove be just as valuable as a cotton field?

There is a real danger to researchers in all this. That is a tendency to continually attempt to deal with purely transitory problems expressed in broad terms. An example from another field may show what I mean.

Suppose that a scientist decides that the span of human life is too short and adopts this as a research problem in itself. Well, it sounds like a good idea and he sells it to the Wonmug Foundation and they give him a billion dollars. An intensive problem analysis shows the automobile to be a big reason why people die young. Next a big program is started to (1) study how to make automobiles safer and (2) also learn why drivers become maniacs when they grasp a steering wheel. All very desirable,but 20 years later when the answers are found there aren't any automobiles-- people are now killing themselves in helicopters and rockets.

In the meantime, some scientists insist on working on such screwball things as the structure of protein molecules, the love life of viruses, azalea galls, properties of solutions, and so on. Out of this come all sorts of ideas (perhaps unrelated to the investigator's curiosity) as to what makes people tick and darn if this isn't applied to help people live longer.

It is very well for us to capitalize on the present great interest in water supply but is it right to imply to the downstream folks that we can accomplish all they ask? For instance, is this a forest research problem-- "How to increase summer yields of water without increasing snowmelt floods" from lodgepole pine lands where snow is the primary source of runoff? Our present knowledge tells us that storage reservoirs to impound spring floods and release them in summer is the most effective way to solve the stated problem. It would be more productive for us to be learning about lodgepole pine, its root system, season of water use, stand density and arrangement in relation to absorption of radiant energy, and also similar things for spruce, aspen, kinnikinick, and other alternative vegetation. What we learn of these things is a permanent contribution to knowledge useful for a wide variety of purposes and provides a sound base to support future work.

Let's keep people interested in watershed management but not let popular statements of "problems" steer research into blind alleys. Also never forget that up till now we don't know very much about how vegetation should be managed for water yields. Who knows for sure whether interception, depth of rooting, a change in canopy, exposure to sun and wind, or what caused flow increases reported for Wagon Wheel Gap, Coweeta, and Fraser? As researchers we should keep on trying to get the facts needed for watershed management. As citizens we have an obligation to consider and question the goals of watershed management.

Fort Collins Research Unit

Snow quality measurements

Snow quality determinations were made at two alpine snowfields at weekly intervals from the middle of July until the end of August 1956. It was thought that the relatively high densities found at these fields the previous summer might be due to a low snow quality (high free-water content).

The calorimeter technique described by Bernard and Wilson (Trans. Amer. Geophys. Union Part I, 1941) was used to determine snow quality. This method involves the use of a thermos bottle, an accurate thermometer, and a graduate cylinder. All of this equipment is delicate and hard to keep intact under the rocky field conditions common to the alpine; however, results were encouragingly consistent.

The two snowfields selected for this study were on the eastern side of the Front Range in central Colorado. The Mt. Evans snowfield

is located on the eastern flank of Mt. Evans, just west of Denver, Colorado. This field forms in the lee of a slight terrace or roll in the topography at an elevation of about 12,500 feet. The Science Lodge snowfield is located at an elevation of about 11,500 feet on the south side of an east-west ridge about 30 miles north of Mt. Evans.

Table 1.-- Snow quality (summer 1956)

Mt. Evans			Science Lodge		
Date	Time	Snow quality	Date	Time	Snow quality
7/18	14:15	96.8			
		86.4			
			8/2	14:30	90.0
					92.7
8/8	12:30	91.5			
			8/14	13:50	87.3
8/15	14:40	94.3			
		95.7			
	(15:30	63.1*)			
			8/21	11:30	83.9
				13:05	87.8
8/22	11:15	95.5			
			8/28	12:00	90.7
					91.8
8/29	11:00	94.9			
		92.7			
			9/4	10:30	88.6
					59.8**
Av. (omitting the 8/15, 15:30 observation		93.47	Av. (omitting the 9/4, 10:30 observation		90.35

* Sample taken in slush at the lower edge of field. Omitted from all averages.

** No evidence of free-water visible. Omitted from all averages.

Snow quality data for the two snowfields are shown in table 1. For the period of record, snow quality was 3.12 percent higher (that much less free-water) at Mt. Evans than at Science Lodge. This difference becomes more pronounced when the two fields are compared for the same time interval. For example, the average snow quality at Mt. Evans for the last half of August was 94.6 percent, as compared

to 88.3 percent for the same period at Science Lodge. The lower elevation and the southern exposure at Science Lodge probably account for the greater free-water content at this field.

Although the free-water content at Science Lodge was a little higher than at Mt. Evans, it was still not high enough to be an important influence on the density. Some other factor or factors must be responsible for the excessive densities found in the summer snowfields. The difficulty experienced in obtaining density samples with the Mt. Rose snow sampler suggested that a check of density sampling techniques and equipment might be the next order of business. The results of these checks will be discussed next.

Snow density sampling

For the past two summers, snow density data have been taken on Rocky Mountain alpine snowfields using the Mt. Rose snow sampler. Recent checks indicate that samples from the Mt. Rose tube overestimate the density. This overestimation results from the unorthodox sampling procedure required by the numerous ice layers or lenses found in the alpine snowfields. It was impossible to drive the sampler through these ice layers unless the tube was empty, or nearly so. Hence, the usual procedure was to empty the tube into a bucket each time a resistant layer stopped the sampler and to attack the layer with an empty tube. The repeated entries into the sample hole, plus the vigorous efforts needed to penetrate the ice layers resulted in snow entering the tube through the slots. In almost every case when checks were made, core lengths exceeded snow depth; hence, densities based on snow depth were greater than those based on core length and in some cases they were ridiculously large.

Twenty-two samples taken at two snowfields were analyzed to compare density as computed from snow depth to that computed from core length and to develop an expression of core length as a function of snow depth. It was found that for samples between 17 and 70 inches, densities computed from core length averaged 9.7 percent less than those computed from snow depth. These samples also showed that core length (in inches) equals snow depth (in inches) plus 5.1 inches. This regression is based on all 22 samples since no difference was found between fields.

As a further check on densities, pits were dug into the snow and samples were taken from the wall, using 500 cc. cylinders. Adjacent to the pits, a Mt. Rose sample was taken and density computed, using both the depth of snow and the length of core. These data are shown in table 2. The pit densities are considered the most accurate. Snow tube data based on length of core was found to be within 5 percent of the pit densities in two-thirds of the cases. Pit densities were consistently lower than those determined from snow tube data.

Table 2.-- A comparison of two methods of determining the density of alpine snow under summer conditions

Date	Method used		
	Mt. Rose snow sampler		Pit
	Snow depth	Length of core	
	Snow density in percent		
August 28, 1956	88.9	73.3	60.9
August 29, 1956	86.3	68.8	63.6
Sept. 4, 1956	87.0	64.5	64.7
Sept. 5, 1956	71.4	77.8*	66.0
Sept. 10, 1956	90.5	69.0	63.5
Sept. 11, 1956	90.2	66.1	65.5

* Probably did not get all the core on this sample.

-- M. Martinelli

Fraser Experimental Forest

The treatment of Fool Creek watershed was completed in October 1956. As of now 278 acres, or 39 percent, of the watershed are cleared of all timber larger than 4 inches d.b.h. Of this acreage, 35 acres are in logging roads, constructed in 1950 and 1951. Two hundred and forty-three acres were cleared by the logging operation that began in June 1954. Of the total watershed area of 714 acres, timber that is unmerchantable because of poor form or sparseness covers 164 acres of the upper portion, and 30 acres of merchantable timber in the form of a streamside strip were left uncut. Thus, half of the area of merchantable timber has been cleared.

The pattern of cutting was one of alternate clear-cut strips, 1, 2, 3, and 6 chains in width and averaging 600 feet of slope distance in length. All strips were normal to the contours to facilitate horse skidding. All live timber 4 inches d.b.h. and larger was cut from alternate strips and all material merchantable as poles, saw logs, posts, or pulpwood was removed from the watershed.

Although the full effect of the treatment on streamflow cannot be expected to appear until the spring and summer of 1957, or perhaps not until 1958, analyses were made of 1956 streamflow to determine if a detectable effect had been realized from the cutting that had preceded 1956.

Preliminary to this, an analysis was made to see if the roads constructed in 1950 and 1951 had had any effect on the streamflow of the years 1952, 1953, and 1954. Only 5 percent of the watershed was affected by the roadway clearance and no effect was detected.

With this result, regression analyses were made using the whole prelogging period of record, 1943-54, for Fool Creek and the control stream, East St. Louis. The analyses were confined to the streamflow records from midspring to early fall of each year since the gages have been consistently operated only during this annual period. Equations were obtained to enable the prediction of Fool Creek flow for: (1) the entire period of gage operation each year, (2) from annual start of record through June 30, (3) July, (4) August, (5) September, and (6) annual, instantaneous peak discharges.

The results from the application of these equations to reveal the effects of logging on 1956 streamflow are shown in the following table, together with the level of statistical significance of each effect.

Table 3.-- Excess of actual over predicted Fool Creek flow, 1956, by months, by season of actual record, and by annual peak

Period	Excess flow					Level of statistical significance
	Inches	Acre-ft.	Acre-ft.per acre cut 1/	c.f.s.	Percent	
5/3-10/12	4.20	250	1.29	---	36.8	0.01
5/3-6/30	2.57	153	.79	---	25.3	.05
July	.13	8	.04	---	10.7	.50
August	.43	26	.13	---	91.2	.01
September	.19	11	.06	---	57.3	.10
Peak	---	---	---	5.67	50.3	.01

1/ Effective area cut is assumed to be that at the end of the 1955 logging season. The volume cut to that time was 79.7 percent of total. The area cut is assumed to be this same percentage of total.

It may be noted that highly significant effects were revealed even though only 80 percent of the treatment had been applied prior to the winter of 1955-56, and in spite of the fact that 1 year of post-treatment record provides an insensitive basis for statistical testing. With reference to water yield, the total seasonal yield and that for August were appreciably and significantly increased, the latter by over 90 percent. As expected, the peak rate of flow was increased because earlier and more rapid snowmelt was favored by the treatment.

Of particular interest is column 4 of the table. This column shows the excess of yield over predicted in a per-acre-treated basis. The seasonal yield from each acre cut is indicated to be 1.29 acre-feet which represents approximately a 100-percent increase.

Our past studies provide no basis for explaining logging effects of the magnitude shown in the table, either when considered on a watershed or a treated area basis. Another year's record is awaited for its evidence on how much of the effects apparent in 1956 were associated with experimental error. In the meantime, we are beginning to suspect that reduced evapo-transpiration losses of soil moisture following logging must be an important factor on water yields, along with reduced snow evaporation. This is contrary to the evidence from earlier, local studies on plots.

We are currently beginning direct observations on the evaporation of intercepted snow. The only quantitative observations made to date were on a pine branch about 2 feet long, suspended in sunlight from a set of spring scales. Freshly fallen snow was thrown on the branch, which easily and firmly held 1/2 pound and could have held much more. Continuous observation was made to note change in weight and any fall of snow or drip of melt water from the branch.

At the end of 2 hours and 40 minutes, 4.5 ounces or over half of the snow had sublimed or evaporated. Air temperatures during the period ranged from 20°- 40° F. The dewpoint was about 7° F. There was very little wind.

On this branch and on a nearby tree under observation, the intercepted snow was observed to become wet with melt water when the air temperature in a weather shelter was still well below freezing. Melting was particularly rapid in the interior of the tree crown, where radiation absorbed by the foliage was most effective. Melt water seeped along twigs below the snow accumulations, but evaporated before drops could form.

For those readers who are attemtping to find suitable scales for snow survey work, Chatillon and Sons have informed us that they will custom-make scales such as we have used for years and found highly satisfactory. Their price is $90. These scales have 90-ounce capacity with a "back-start" of 30 ounces, leaving a snow-load capacity of about 60 ounces when two sections of snow tube are used. The scales have a plastic dial cover, are convenient to use when mounted on a suitable pack frame carried on the chest, and are accurate after years of rough use. (I wouldn't trade mine for three of Northeastern's steelyards with built-in beer-can openers.)

-- B. C. Goodell

Tempe

Phreatophyte project

Field work has started in the new phreatophyte project. Little has been written about the characteristics and ecology of the individual phreatophyte species of the Southwest. Such information is needed as a basis for management if manipulation of the vegetation for decreased water-loss appears to be possible.

Transpiration apparatus.-- Perhaps the most important information to be gathered is a determination of the comparative water use of the various associations and their component species. For this purpose an apparatus measuring water-vapor production by means of an infrared gas analyzer as a highly sensitive hygrometer is under development for field use. A small laboratory model of an open-circuit apparatus has been constructed and tested. It does not have noticeable sensitivity to temperature change and thus avoids the major difficulty of the previous closed-circuit apparatus. It has been used to record directly and continuously the transpiration rate of single twigs of tamarisk (and single leaves of eucalyptus) under a variety of experimental conditions and treatments. Results of the study were reported at the Phreatophyte Symposium of the American Geophysical Union meeting at Sacramento in February.

Planned for the immediate future is the construction of a pilot model of a field apparatus. It will be large enough to take a 3-foot potted tree and will allow direct comparison of measurements made simultaneously by three radically different methods: (a) vapor production, (b) gravimetric, (c) heat transfer along the stem.

-- J. P. Decker

Basic ecology.-- Needed ecological information on the principal species is being obtained from designated study areas containing sample plots, transects, etc. Establishment of field plots has been started to determine the period of active growth and the time of seed production and dispersal for the principal phreatophyte species and to evaluate the effect of such environmental factors as altitude, temperature, and soil moisture upon these phenomena. Other sample plots have been laid out to study the influence of site and climatic factors upon seed dispersal, seed germination, and seedling survival. Seed germination is also being studied in the laboratory.

Another major problem is the aggressive spread of tamarisk into new areas, particularly into higher altitudes. Transects and photo-stations are being established to determine how rapidly tamarisk is spreading and what factors are influencing this spread.

-- J. S. Horton

Timber cutting on Workman Creek

The first treatment on the North Fork of Workman Creek, removing Arizona alder and bigtooth maple along the main channel (totaling 0.6 percent of the basal area of trees on the watershed), was completed in August 1953. To date no significant change in either annual or summer streamflow has been detected from this small riparian cut. Even though the sample of years covers primarily a drought period, it appears that a small amount of vegetation removed will not significantly change water yields. Diurnal fluctuations have persisted after treatment. It is possible that the trees remaining along the stream channel (white fir) have fully occupied the site and have thereby maintained water usage.

The first treatment on the South Fork of Workman Creek--timber harvest and silvicultural treatments that removed 36 percent of the basal area of trees 1 inch and larger--was started in 1953 and completed in 1956. Timber harvest and improvement work was spread over 4 years. Timber harvest and improvement work was by individual tree selection rather than group or block cuttings. Remaining basal area of trees 12 inches d.b.h. and over is 60 square feet per acre. This large residual stand, released by harvest of mature and overmature trees, should reoccupy the site in minimum time. Since cutting was spread over 4 years it is possible that some of the first areas harvested were at lease partially re-occupied before the treatment was completed. This may minimize the overall effect. In any event, the effects of a gradual change rather than a sudden or shock change, such as follows fires or a harvest completed in a short period of time, will be measured.

The first year's treatment data from South Fork will be available October 1, 1957. No effect of the incomplete cut was detected during the 1955-56 water year. Precipitation in that period was only 24 inches and streamflow only 60 percent of normal. These drought conditions may have masked the initial effects of the timber harvest.

Soil movement on a chaparral site after burning

Soil movement on granitic soils after a chaparral burn near Globe, Arizona, has been appreciable in spite of the fact that the area was seeded to weeping lovegrass. Measurements were made at 5-foot intervals along 100-foot transect lines. Nine transect lines were located on a grazed area (grazed since 1952) and nine transects in an ungrazed exclosure. Initial measurements of soil movement were made in November 1952, 1-1/2 years after the burn. Measurements were repeated in August 1956. Differences between initial and subsequent measurements are expressed in the tabulation below as follows: (1) Total change on the 378 points without regard to sign, (2) average depth of cutting, (3) average depth of fill, and (4) average net change based on the differences between the totals for cut and fill. Grass and shrub densities for 1952 and 1956 are also shown in the tabulation.

	Difference between measurements in November 1952 and August 1956	
	Grazed area Feet	Ungrazed area Feet
Total change	0.07	0.07
Cut	.06	.07
Fill	.08	.09
Net change	+.001	+.01
Grass density	-.05	+.56
Shrub density	+20.30	+15.03

Total soil loss from the area has been small because changes in cuts and fills almost balance. However, soil is shifting over the

surface, in most cases toward existing gullies. Maximum depth measured was 0.48 foot. Material that has been moved as far as the gullies will surely be flushed out of the area when larger storms occur.

3-Bar cooperative study in the chaparral zone (elevation 3,500 feet)

Weirs were completed on 4 experimental watersheds in June 1956. These watersheds are located about 8 miles northwest of Roosevelt, Arizona, and 10 miles south of Reno Ranger Station. Annual precipitation at Roosevelt averages 15.57 inches and at Reno 18.49 inches.

Summer rains produced no runoff. First runoff on the watersheds occurred January 9, 1957. Rainfall during December 1956 totaled 0.42 to 0.53 inch at the watersheds. January 1957 totals were 13.19 and 14 inches. Peak discharges of nearly 25 and 50 c.s.m. were recorded from 78- and 50-acre watersheds and 0.6 c.s.m. from the 274-acre watershed. The fourth watershed yielded no runoff. February precipitation totaled between 1.53 and 1.67 inches and resulted in almost continuous flow from two of the watersheds during most of February and into March 1957.

-- L. R. Rich

Grand Junction

Water-use study

The study of relative water use by aspen, spruce, and herbaceous vegetation which was discussed in the last semiannual report will be continued during the 1957 growing season. We are changing the design of the study somewhat in an effort to reduce sampling error. The 1955 measurements, which showed that aspen used almost twice as much water as the other species, need to be continued for several growing seasons before valid conclusions can be drawn.

A correlation of 1955 water use data with the vegetation density within each vegetation type has brought out some interesting facts. Total herbage production on plots in the Idaho and Thurber fescue types was found to be closely correlated with the amount of moisture withdrawn from the upper 4 feet of soil.

One of the most interesting findings was that on the Thurber fescue type much more herbage was produced in proportion to the amount of water used than on the Idaho fescue type. This is shown in the following tabulation:

Vegetation type	Plot	Water use (Upper 4 ft. of soil) Inches	Total herbage production (Lb. per acre)
Idaho fescue	1	6.5	1,186
	2	8.2	1,479
	3	4.5	831
	4	4.3	787
Thurber fescue	1	9.3	2,684
	2	7.4	2,569
	3	7.3	2,559
	4	5.3	1,997

-- H. E. Brown

Flagstaff

In November 1956 Willie R. Curtis and Earl F. Aldon joined the Flagstaff Field Unit to initiate watershed studies in the ponderosa pine and pinyon-juniper woodland types. Emphasis is being placed on streams that furnish water to the fertile soils and the thriving cities of the Salt River Valley.

Little is known of the hydrologic factors influencing water yields in the pine "fringe" woodland types. Management practices designed to "increase water yield" are now being carried out on a pilot basis.

The Arizona Watershed Management Project (Beaver Creek project) is a National Forest Administration program designed to treat subwatersheds by methods intended to increase water yielded to streams. Treatments planned are to remove juniper, thin pine, and remove other tree and brush growth of low value in an attempt to increase streamflow.

Three groups of three small watersheds each will be gaged to evaluate these land treatments. One group is in the Utah juniper type, one group is in the alligator juniper type of high elevations, and the third group is in the ponderosa pine type. Rain gages and other weather instruments are being installed on each group of small watersheds. Research personnel will assist National Forest Administration in the gathering, analysis, evaluation, and interpretation of the field data.

Additional studies are to be initiated to assist in understanding hydrologic conditions found on the project area. Pine and juniper precipitation interception, sediment production from small watersheds, and soil moisture-streamflow relationship studies are ready for field installation.

-- Earl F. Aldon

Rapid City

Population of the Black Hills area, like many other parts of the West, has increased rapidly in recent years. This in itself has created water problems. Increasing public concern is evident in agitation for more definite watershed management programs and plans.

Some of the local watershed problems rise from unique physical characteristics of the area and some from past and present land use. Soils, geology, and topography are extremely variable. The climate and precipitation patterns are more like those of the adjacent plains areas than other mountain areas of the West. The extensive ponderosa pine stands on national forest land have been under relatively intensive management for many years. Small ranch and farms are scattered throughout the hills, making a complex ownership pattern. Domestic livestock and big game graze on both private and national forest land. And the limited area of the grass type range encourages intensive use--particularly in the stream bottoms.

Recreation use of all kinds is increasing rapidly, emphasizing the need for expanding facilities and more consideration of recreation needs in management plans.

A watershed management project analysis is under way. In the meantime exploratory work has been started on what appear to be some of the more serious problems.

Bulk density and pore space of soils

A problem which has aroused public concern and comment, particularly among sportsmen groups, is the reported increasing flashy nature of streamflow from high intensity summer storms. Speculation has been that this is the result of reduced infiltration caused by livestock trampling, mainly in bluegrass stream bottoms. As previously reported, an exploratory study was initiated during the summer of 1956 to try to find out if the medium textured stream bottom soils have been compacted. Since there are virtually no range areas that have not been grazed, it was necessary to study soil conditions inside and outside of livestock exclosures. This gets at the problem from the back door, so to speak, since the study had to be designed to show possible recovery from soil compaction under protection from grazing use.

Laboratory analyses and computations of bulk density and pore space of soils are near completion. Measurements were made inside and outside four livestock exclosures protected from grazing for 6, 7, 10, and 17 years respectively. Tentative results show a significant reduction in bulk density and increase in noncapillary pore space from the soil surface to 4 inches inside the two exclosures protected for 10 and 17 years. Differences between inside and outside were vague or nonexistent at the 6- and 7-year-old exclosures.

From 4 inches to 1 foot there were no differences in soil properties inside and outside any of the four exclosures that can be associated with grazing use.

Results are summarized in the following table

Depth (Inches)	Exclosure and number of years protection							
	Victoria - 17		Dutchman - 10		D Ranch - 7		Nigger Creek - 6	
	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
	Bulk density (grams per cc.)							
0-4	0.86	0.96	0.80	0.99	1.12	1.08	1.02	1.06
4-8	.92	.96	1.08	1.12	1.14	1.12	1.07	1.04
8-12	.98	.99	1.27	1.19	1.16	1.24	1.08	1.06
	Large pore space (percent of soil volume)							
0-4	20.6	12.8	17.2	9.7	18.5	16.2	11.2	9.0
4-8	17.1	18.4	11.6	11.9	19.4	19.0	10.0	11.8
8-12	16.4	20.0	8.0	12.4	19.1	14.8	11.3	12.7

Results show that grazing does compact the soil at least to a depth of about 4 inches. They also show that soils will recover from the effects of compaction under protection from grazing. Too small a number of sites were sampled to show conclusively how long a period of protection is necessary before there is a significant degree of recovery. But the results suggest a minimum of 7 to 10 years.

We are not yet in a position to evaluate results in terms of specific effects on infiltration and percolation of water into the soil. However, results from other studies strongly suggest that measured differences in noncapillary pore space inside and outside the two older exclosures are great enough for infiltration and percolation rates to be significantly different. Then there is logical reason to tentatively conclude that compaction of stream bottom soils can cause an increase in surface runoff and flashy type streamflow.

Results thus far indicate the desirability of setting up a more comprehensive study to more specifically determine rates of recovery from soil compaction and the effects of different types, intensities, and seasons of grazing use.

Precipitation-streamflow relationships in the Black Hills

An analysis of precipitation-streamflow relationships is needed to show when, where, and how water flows in Black Hills streams. The analysis will be based on existing records. Just how well the objectives are met will depend on the accuracy, coverage, and completeness of available data.

As noted in the last report, collection of data is under way. A concerted effort will be made to complete collection and analysis of data and a report within the next few months. Aside from the primary objectives, results are expected to show if and where additional precipitation and streamflow measurements are needed to round out the picture. There already appears to be a shortage of information for the higher elevations, which are the primary water yielding areas of the hills.

-- Howard K. Orr

Albuquerque

In the Rio Grande Basin the main problem is "soil out of place." The Rio Puerco is the most critically eroding segment, contributing almost half of the sediment into the main river channel. Thus, any research that this small research unit might undertake should be aimed at some possible solution to the soil erosion and sediment problem-- for the problems of the Rio Grande cannot be solved without first meeting those of the Rio Puerco. This is a problem of land management for other agencies early recognized (in the thirties) that large engineering structures were not feasible for control of sediment in the Rio Puerco. We also realized quite early that any solution, even partial, is a tremendous undertaking and beyond our limited resources. A cooperative or joint effort appeared most promising. Shortly after this unit was established we entered into a cooperative undertaking with the Bureau of Land Management and Geological Survey.

Three watersheds (431, 591, and 680 acres) in the Rio Puerco drainage were selected primarily on the basis of accessibility and because this is the only area in which some regulation of livestock numbers and season of use can be obtained. All other areas in the Rio Puerco are grazed by Indian-owned livestock and even limited "grazing control" is entirely out of the question. These watersheds were seriously abused in the past and although pock-marked with narrow, deeply incised gullies, some soil and vegetation recovery appears to have taken place under controlled use, in spite of the most serious drought in the Southwest since precipitation measurements began.

The primary objectives are to determine how water and sediment inflow, measured at the reservoirs, are affected by cattle grazing and mechanical land treatments. Other objectives include the determination of the relationship between erosion, sediment, waterflow, precipitation, and vegetation. We would also like to determine the relative contribution from land slopes and gullies to the measured sediment load, the pattern of soil movement over the watersheds, and an index of the rate of aggradation and degradation as related to watershed conditions.

We have attempted to interest the Geological Survey in evaluating the causes of gully formation and their rate of change for we believe this phase rightly belongs to them and we realize they, no doubt, are much better qualified to handle these investigations. Our

efforts are being directed toward land slope erosion as related to soil and vegetation conditions.

We are presently attempting to calibrate the watersheds under uniform conditions of use. Our main difficulty is "methodology." We have studied the literature and given considerable thought in developing equipment, methods, and procedures but have not come close to solving this problem.

Four main measurement difficulties are involved. These are:

1. How to accurately measure sediment inflow at each reservoir. This involves bulk density and compaction of sediment as well as changes in elevation of sediment.

2. How to measure suspended sediment outflow over each spillway and through the culvert pipe on one of the watersheds.

3. How to measure the changes in present gullies and rate of formation of new gullies.

4. How to record and evaluate soil movement and deposition taking place over the land slopes between the gullies.

Changes in reservoir sediment volume are currently measured by two methods; one utilizes several series of thin metal plates permanently installed in the reservoirs while the other involves taking sediment cores with large diameter lucite cylinders. Suspended sediment will be measured by aliquot samplers. Soil aggradation and degradation will be measured by means of soil transects.

Palpant explains some of the methods we are now testing and using to evaluate soil changes and sediment inflow. We need help on these problems and welcome any suggestions and ideas.

-- E. J. Dortignac

In a recent report, the question was raised by the Washington Office concerning the possible determination of sediment compaction associated with the Pacific Northwest station measurement of sediment in basins. After considering numerous methods for determining the amount of compaction we decided to use metal plates, placed on top of the sediment after each major period of waterflow. The objective is to measure the change in level or height of the plates with time and as additional sediment layers are deposited, measure the position of each imbedded plate.

The setup consists of a series of sampling points with a 1/2-inch metal rod driven into the basin marking each position and loosely holding the 1-foot-square metal plates. A 2-1/2 inch diameter hole is cut into the center of the plate permitting independent movement of each plate from the 1/2-inch diameter rod. Galvanized sheets (32 gage) are used. It is assumed that pressure

from the weight of the metal plates is small. To measure the position of the plates a wire is soldered to the plate and bent at a 90° angle to the plane of the plate. It, then, is adjacent and parallel to the reference rod and held in position by wire loops fastened to the reference rod. The length of the wire on the plates is recorded. Distances between the tip of the plate reference wire and the stable reference rod are recorded at intermittent intervals. Changes in distances should be a direct indication of changes in sediment density and afford an opportunity for determining the true volume of sediment deposited during any period of time.

This coming summer field efforts will be concentrated on the Rio Puerco experimental watersheds. Soil transects, 100 feet in length, marked at each end with metal rods will be established over the watersheds. Soil elevations will be determined with a precise engineer's level and rod at regular intervals marked by a steel tape stretched taut between the metal stakes. Permanent benchmarks will be established in exposed bedrock for permanent tie in to the metal stakes.

Smaller sized (6 to 7 feet) soil transects, similar to those installed at Pine Flat, will also be used in the Rio Puerco. Three small (3 feet) transects were established adjacent to the infiltration study site at Pine Flat in the Manzano Mountains east of Albuquerque. The objective here was to correlate changes in soil structure (surface elevation) with infiltration from season to season. The transect posts are 3/8-inch steel rods driven 30 inches into the soil to bedrock. The top of each rod is about 6 inches above ground level. By placing a stainless steel straightedge across the top of the rods, readings can be taken to 1/32 inch. Readings were obtained at every inch along the 36-inch transect. Two small devices held the straightedge in position and positioned the steel ruler at each reading, thus eliminating human error in placing the ruler on the ground.

A total of 100 measurements were obtained at each measurement period. The mean values showed a steady decline in soil level during the rainy summer period. Then after the thawing and freezing period began in October, a rapid rise was noted so that at present a maximum rise of 7/10 inch has been measured from the August 1956 low point. This may be surprising considering the climatic zone, but it does indicate that there is a continual change in soil structure in the topsoil varying with moisture conditions and seasonal changes.

--E. H. Palpant

Comments

"Effect on streamflow of cutting a forest understory" by Johnson and Kovner, Forest Science, June 1956. -- Kovner appreciates the comments by the California station in the April-September 1956 report and regrets that the original article was not

more explicit. He hopes the following discussion will aid in understanding the methods used.

Concerning the points raised by R. A. Merriam, in the analysis of variance or covariance the experimental error variance is a pooled estimate. It is generally customary to test the individual group variances for homogeneity using the F-ratio for only two groups or Bartlett's test for more than two groups. When the null hypothesis regarding the homogeneity of the variances is not rejected, the variances are considered as homogeneous and belonging to the same population, so that a pooled estimate of the variance may be obtained.

With reference to page 327 of Snedecor, table 127, the analysis of variance table tests the difference among group regression coefficients (first line of last paragraph on page). Obviously if the slopes of the individual lines do not differ significantly, the lines may be regarded as parallel.

The only reason for going to the trouble of establishing the parallelism of the lines was to make possible a simple test for the significance of the distance between the two lines as indicated in the text, that is, to test if the mean increase in streamflow of the treatment period was significant. Perhaps it would have been less confusing to the reader to make a direct test for the mean increase in streamflow. (Reference Schumacher and Chapman, "Sampling Methods in Forestry and Range Management," p. 134.)

Consider, however, that the regression for the calibration and treatment periods may be represented, respectively, as

$$Y_c = a_1 X_{1c} + b_1$$

$$Y_t = a_2 X_{1t} + a_3 P + a_4 t + b_2$$

where Y is annual streamflow on control watershed, X is streamflow on control watershed, P is annual precipitation on treated watershed, t is year since treatment. Then it is possible, and, in fact, generally should be the case, that a_1 and a_2 and the difference or treatment effect is given by

$$Y_t - Y_c = a_3 P + a_4 t + b_2 - b_1$$

This is basically the analysis used in the paper.

An example of this situation is given in the semiannual report of the Division of Watershed Management for the period October 1953 to March 1954, Coweeta Hydrologic Laboratory, page C-5. The regression coefficients of Y on X_1 for the calibration and treatment periods are not significantly different and the regressions are given by

$$Y_c = 34.90 + 0.9148 (X_{1c} - 38.47)$$

$$Y_t = 42.30 + 0.9148 (X_{1t} - 37.33) - 0.5971 (X_{2t} - 7).$$

where X_{2t} is the year since treatment. Note that the common or pooled regression coefficient is used. Then the treatment effect in a given year is

$$Y_c - Y_t = 8.30 - 0.5971 (Y_{2t} - 7)$$

Originally the pooled or average regression coefficient was used in estimating the annual increases in streamflow and the trend similar to that indicated in table 3 of the article was obtained. Actually the estimated increases are not greatly different when computed using either the pretreatment or average regression coefficient. Note, however, that the treatment period regression coefficient of Y on X_1 is affected by the introduction of P and t, and for that reason the pooled estimate obtained was not used.

The following statement by Merriam is not clear: "Is it coincidence that when this first year's data is dropped the precipitation becomes nonsignificant in the resulting analysis?" Obviously inclusion of the first year's data would only make matters worse as far as precipitation is concerned. The only reason for omitting the 1949 data was to try to improve the streamflow-precipitation relation on the basis that some unknown factors affected the result.

No serious objection can be taken to the remarks regarding the exclusion of the first year's data for the growing season. It is very difficult to explain the behavior of the data, but we were not certain that the result was due entirely to the unusual amount of precipitation. For example, the first growing season following cutting the laurel and rhododendron retained practically all of its foliage while on the ground and the true effect of the treatment would not take place. The fact that precipitation minus runoff was the lowest on record for this year, as noted in par. 5, is not too important since no adjustment was made for ground water storage.

No attempt was made to explain the results of this treatment in terms of physical processes as suggested in par. 6. Several of the reviewers suggested that we offer the reader more information on what was actually happening in terms of storage, interception, etc. From the data at hand this gets very involved and after a while all one does is chase one's own tail.

Whether to publish the results of this experiment with the data at hand is a matter of judgment. I believe the results are very important and interesting. The paper makes no claims as to the finality of the results and indicates that the experiment is being continued. Certainly all reviewers were competent individuals. It was their considered opinion that the paper be published.

The comments by Arnold Court are undoubtedly appropriate for some watershed studies. With regard to the watersheds in question the following points should be considered:

The values of streamflow in table 2 are all in excess of 40 inches and therefore cannot be expected to offer any reliable information about the behavior of the coordinate points at or near the origin. We are studying the effect of the treatment over the observed portion of the entire range of possible flow values. The linear model would hardly apply from 0 to very high flows and the regression line fitted to the observed values should not be extrapolated to the origin with any kind of confidence. The constant term in the regression model may turn out to be positive, zero, or negative. One is not justified in imposing a boundary condition at the origin to the linear model.

The regression for the treatment period is given by

$$Y = -2.24 + 0.9987\ X$$

The constant term is significantly different from zero. In this case the behavior of the line extrapolated to the origin is presumably consistent with the observed data and there would be little justification in using an alternative form

$$E\ (y \mid x) = bx$$

It may be well to consider the implication in physical terms of the assumption that the curve pass through the origin. It would mean that the streamflow on the one watershed would be either equal to, greater or less than that on the control watershed over all ranges of flow, and without rain the two adjacent watersheds would then be expected to run dry at about the same time. Experience has shown, however, that no two watersheds respond in the same way to similar weather regimes due to differences in a variety of physical features such as area, configuration, slope, topography, aspect, soil depth, and vegetative cover. At Coweeta we find that where the streamflow on watershed A exceeds that on a nearby watershed B for high ranges of flow, the reverse may be true for lower ranges. For example, monthly streamflow totals during the late summer and fall reverse the winter and spring relationship. Therefore, annual values would be expected to do the same at low flows, say, below 15 inches. The phenomenon is probably due to differences in the reservoir storage capacity of the watershed soils.

In view of the above the classic linear regression $E\ (y \mid x) = a + bx$, when fitted to the observed data by the method of least squares leads to a reasonable estimate of the treatment effect for the observed range of flows.

-- J. L. Kovner

"Water Yield and Public Land Management." Jour. of Soil and Water Conservation 11:157-162. 1956

This is recommended reading and represents the way Rosa and Croft are reacting to the same sort of a thing that causes Hoover's outburst

in the introduction to this issue of the semiannual report. The article concludes: "no long-time gaging records are known to exist in this region* which clearly show any significant change in total annual streamflow (after climatic factors are recognized) which could be attributed to improved vegetation or past land use changes on the watershed."

It is easy to agree with the author's statement because of the inadequacies in past runoff and precipitation records and an almost complete lack of information on changes in plant cover. Yet do the authors believe that total water yields are actually independent of plant cover type and density?

* Intermountain Region.

-- Marvin D. Hoover

"Snow Accumulation under Red Pine of Different Stand Densities in Lower Michigan." Lake States Tech. Note No. 460, July 1956

This one draws fire from Hoover. He is patient with people who insist on measuring snow depth but doesn't believe they should be allowed to draw conclusions about precipitation reaching the soil. The writeup is misleading because the reader is led to believe that water content of the snow was measured. Also the possibility of differential melting beneath the trees and in the open is ignored. The study does not support the conclusion "Decreasing the stand density by thinning also increases the amount of precipitation reaching the soil."

-- Marvin D. Hoover

"Soil Water Depletion by Pine and Hardwood Stands During a Dry Season." Forest Science 1: 258-264, 1955.

This study by Robert Zahner provides useful information but not enough to support "theories that evapotranspiration within a given climatic area is independent of the type of forest cover." Records of soil moisture were taken in two 50 x 50-foot plots in 35-year-old oak and in two 50 x 50-foot plots in 20-year-old pine. Soil moisture was sampled periodically between May 19 and September 8, 1954, between depths of 6 and 60 inches. The period of study was too short to draw any conclusion about total annual evapotranspiration and was limited to a dry summer. Without consideration of possible differences in soil moisture withdrawal throughout the year, the author should not speculate about total evapotranspiration.

Incidentally, was it proper to exclude the 0 - 6 inch depth layer? Are the total depletion rates meaningful when that layer is excluded "because the moisture content ... fluctuates so greatly with occasional showers."

-- Marvin D. Hoover

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

October 1956 - March 1957

COWEETA HYDROLOGIC LABORATORY

Coweeta reports for the semiannual report of the Division of Watershed Management have been composed in the past of two quarterly reports as written to meet the progress report requirements of the Southeastern Station. Starting with January 1 of this year, the latter reports will be made semiannually. It is intended in the future to submit the Station semiannual report for inclusion in this publication plus a discussion of our thinking at Coweeta on watershed management research problems. This issue will include the last quarterly report plus discussion.

The discussion for this time will be on methods of measuring or estimating evapo-transpiration. This disucssion is being presented at the request of Herb Storey. As noted in the quarterly report, Whelan attended a stimulating meeting of the ASAE in Chicago in December 1956 on evapo-transpiration. The most revealing feature of the meeting, which I suppose is not too surprising, is how much we have to learn about evapo-transpiration. Most people agreed that annual, seasonal, and monthly values of evapo-transpiration can be estimated fairly reliably. We have some success with weekly values, and on daily values we can go simply hogwild.

L. T. Pierce, USWB State Climatologist, Columbus, Ohio, gave an interesting paper on the "Determination of Crop Moisture Deficit in Ohio." Pierce used Thornthwaite's "water budget" method as modified to check the E-T values as obtained from the weighing lysimeters at the ARS research station at Coshocton, Ohio. The results were not too satisfactory, but Pierce feels it has possibilities for the prediction of weekly E-T values.

G. Levine of Cornell University compared the methods used today for estimating E-T. The three broad groups he discussed were empirical methods, theoretical methods based on the removal of vapor, and theoretical methods based on the balance of energies available and used. Thornthwaite's and Penman's are the two most widely used, but both leave a lot to be desired since they both met with varying degree of success and failure.

Since Penman criticized the results at Coweeta, we have been reviewing very carefully our past work and the literature on evapo-transpiration. The following discussion onthis subject has been prepared by John Hewlett and represents our current thinking on this subject and gives some clues on how we are intending to attack this problem in the future. We would appreciate comments from anyone interested in this problem. We would particularly like to know if you think we are heading in the right direction.

Problems in Estimating Evapo-transpiration from Forest Land

It has been demonstrated at Coweeta that water yield from forested watersheds in a high rainfall belt can be increased by drastic reductions in vegetative cover. In attempting to predict the amount of increase to streamflow resulting from a manipulation of vegetation, we must know the magnitude of the evapo-transpiration before and after the changes are made. In such empirical evaluations of watershed treatments as those at Coweeta, it has become a fundamental procedure to accept the difference between long-term averages of precipitation and runoff as the net loss of moisture to the atmosphere, referred to generally as "evapo-transpiration" (= E_T). This approach to understanding the water balance has been called the solution by the residual method.

Another method of approximating evapo-transpiration has been developed along entirely different lines. This technique is based on the theory of the energy balance and has reached its highest level of application in the work of Penman and Thornthwaite. Under the principle of the conservation of energy, it is reasoned that more energy cannot be used in heat transfer, radiation and evaporative processes at the earth's surface than is received from the sun in radiation. Using meteorological data, the total energy received is apportioned to the various dissipatory processes, including evaporation. The role of vegetation in this scheme is assumed to be passive and to have only indirect influences on rates and apportionment. The technique has proved of considerable reliability under various climatic conditions, and formulas have been developed for the prediction of evapo-transpiration. However, checks against their applicability have been drawn chiefly from crop- and pasture-land vegetation. Because of the difficulty inherent in estimating E_T from forest land by the residual method, there has not been a sufficiently reliable test of the applicability of these formulas to such land.

It is to be expected that a comparison should be made between estimates of E_T based on the two methods. It is in fact a fortunate circumstance that we have the two techniques to serve as counter checks, since neither method seems of itself to offer the final solution of the water balance equation for forest land. Penman has found that the precipitation and runoff values at Coweeta provide an unusual example of the failure of the two methods to furnish similar estimates of E_T. Using data from two Coweeta watersheds, he estimates by his formula an annual water loss which is approximately 25 percent less than that indicated by our data.

As a result of the failure of the energy balance formula to predict observed results at Coweeta, Penman has made what seems to be a legitimate suggestion that our data may need reexamination. Many interrelated factors are involved in Penman's theoretical equation, with the result that the validity of the method lies not only in the soundness of the physical principles employed but also in its ability to predict E_T under given circumstances. Thus it cannot be checked against itself, but must be adjusted to satisfy observed data, assuming that the latter comes from a situation which meets the basic conditions of the formula. A failure to predict the results of a field test logically calls for a reexamination of the test to see if the disagreement is more apparent than real. Coincidently, the hypotheses upon which the formula is based should be reassessed against the possibility that the field data from which it so radically deviates are approximately correct, with an eye toward finding a measurable parameter from which to apply a correction factor to the formula.

A reappraisal of Coweeta water balance results is under way. At the same time, an attempt is being made to develop a new approach to the solution of the water balance equation, with particular reference to incorporating the principles of the energy balances formulas. There can be little doubt that the energy balance concept contains a large part of the answer to the intricate problem of evapo-transpiration. It seems likely, however, from the present record that the formulas will have to be modified in order to apply them to forested watersheds in the Southern Appalachian Mountains.

The reliability of the residual method is based on the accuracy with which two components of the water balance equation are measured. These are precipitation and runoff. Errors in the precipitation estimate can stem from (1) insufficient number of raingages, (2) misinterpretation of the raingage network and (3) failure to catch in the gages all components of water input. Errors in runoff can stem from (1) errors in installation and calibration of the weirs, (2) errors in surveying the watershed boundaries and (3) leaks into or out of the watershed.

The water balance equation as generally used at Coweeta is in the form:

$$P = I + E + T + RO \qquad (1)$$

in which: P = Precipitation

I = Interception and re-evaporation of rainfall from vegetation

E = Evaporation from the ground surface

T = Transpiration

RO = Runoff (Streamflow)

If calculation of the water balance is restricted in time (that is, to less than several consecutive years of record) two other components must be added to the equation. These are changes in soil moisture and ground water storage from the beginning to the end of the observation period.

$$P = I + E + T + RO \pm \Delta SM \pm \Delta GW \qquad (2)$$

Methods are available for estimating these storage quantities when short-term yield is being studied. For purposes of estimating long-term P-RO values, changes in storage can be neglected if the water year May-April is used consistently.

For purposes of this discussion a slightly modified water balance equation is presented:

$$E_T = P - RO + C + (L_i - L_o) \qquad (3)$$

in which:

E_T = all losses of moisture to the atmosphere, including I + E + T

P = Rainfall in the open from standard rain gages

RO = Runoff (streamflow)

C = Condensation of moisture on vegetation or ground

$L_i - L_o$ = additions to or subtractions from streamflow due to leaks into or out of the watershed.

Again allowances must be made for changes in storage if short-term results are being studied. A discussion of the components of this revised equation follows.

Runoff is the most consistently reliable measurement of all the input-output quantities on the watershed. It is a total measurement and depends for accuracy chiefly on the construction and the calibration of weir, assuming of course that the drainage area has been properly surveyed. The calibration of the stream gages at Coweeta have shown an error of less than 3 percent over a considerable range of streamflows. However, even a perfectly functioning weir is no guarantee against leaks in the watershed above the weir. It has always been assumed that such leaks were at a minimum at Coweeta. The granitic country rock is abundantly folded, the folds lending sharp outlines to the well-defined unit watersheds. These folds would seem to leave little chance for the existence of long slanting aquifers to channel water from one drainage pattern to the next. This, of course, is speculation, but fortunately there is an indirect check on the presence of large leaks to be derived from an analysis of the whole network of streamgages at Coweeta. To put it simply, the sum of the runoff from several unit watersheds of similar topography, soils, vegetation and elevation should approximate on a unit area basis the streamflow from each

included watershed. General comparisons along these lines have been made at Coweeta, resulting in the conclusion that the precipitation-runoff values for watersheds at the same elevation are in fair balance with one another. There is a need, however, to systematize these comparisons so that each watershed may be rated as to its probable fitness for use in the solution of the water balance equation.

Precipitation is measured by a sampling technique which provides inherently weaker data than the total measurement of runoff. There exists a possibility that the Coweeta raingage network is inadequate to furnish sufficiently accurate estimates of the total rainfall on the unit watershed. A study is underway to test this possibility and to strengthen the values in such an eventuality. Results from this study are expected to be of great value in strengthening P - RO comparisons between similar watersheds, as discussed above.

Heretofore, condensation has been largely ignored at Coweeta on the assumption that it is absorbed by the interception component in the standard water balance equation (1). This is probably true, but the relation of both condensation and interception to water losses appears to change under the energy balance concept. Evaporation of these two components in this case must result in net savings to soil moisture, since limits on the total evaporative rate are set by meteorological conditions. Interception is included in the measurement of precipitation and therefore as a component of E_T is accounted for in equation (2). Condensation on the other hand must be added to the equation since through its influence on soil moisture it has an overall tendency to increase streamflow. This influence must be slight, but we have no way at present of making even a rough estimate of it in quantitative terms. One of the contributions of the energy concept has been to point out a need for enlightenment concerning these components of input which do not contribute directly to soil moisture and runoff.

Pending these reevaluations of the precipitation-runoff-evapotranspiration relations at Coweeta, we are proceeding with plans for the adjustment of Penman's formula to meet forested conditions in the Southern Appalachians on the assumption that its wide disparity is unlikely to be entirely due to errors in Coweeta measurements. In spite of the energy conservation concept, as embodied in Penman's formula, it does not seem quite reasonable that annual E_T losses from short-season, homogeneous, relatively shallow-rooted field crops should be the same as the losses from perennial, heterogeneous, deep-rooted, two-storied forest vegetation of the type covering the Southern Appalachians. The results from several Coweeta studies lend weight to the idea that the annual water loss rate based on meteorological data is quickly reached and passed on watersheds which have been clear-cut. For example, Watershed 13 was clear-cut and allowed to regrow. Annual water losses were reduced from 37" to 22" the first year and have shown a gradual increase ever since. If the water loss as computed from climatic data are compared with those estimated from streamflow for the second or third year after treatment, a fairly close

agreement is reached. It might be reasoned that this period represents the time when the sprouts and herbaceous plants succeeded in completely covering the ground. Watershed 17 furnishes a further example. Although it has been "clear-cut" each year, the effective treatment has been to convert a forest stand to a more or less complete cover of sprouts, herbs, grasses and briars, which satisfies the principal requirement for the application of the energy balance equation - namely, that the ground be completely occupied by vegetation. The average P-RO of the last six or seven years of treatment has been approximately equal to the theoretical value derived from Penman's method.

Further evidence that E_T rates are larger than formula-predicted values exists in measurements of soil moisture deficits through the growing season. Moisture deficits from six plots at various elevations on Coweeta have been plotted over the calculated rate of E_T. There is a striking difference between the predicted withdrawal of soil moisture and the actual withdrawal as reflected in the soil moisture deficits. The energy balance formula apparently underestimates the water consumption during the growing season.

The implications of these observations are not that the energy equations are useless in forest land but that they have perhaps been applied beyond the limits of their original conception. The total energy received from the sun is a finite quantity which can be fairly closely measured or estimated. Penman lists the main losses of this energy as (1) reflection of solar radiation, (2) net back radiation to the atmosphere, and (3) heat transfers to or from the atmosphere, and (4) evaporation. A decrease in the energy used by any of the first three forms of loss implies an increase in the energy used to evaporate water. The question arises whether or not the relation between these four forms of energy loss remain constant for both field crops and dense forest land. In particular, there would seem to be some room for doubt that heat transfer to or from the atmosphere would be independent of vegetation size.

Since the results from watershed 13 indicate a tendency for water losses as reflected in P - RO to increase with increasing height, stem density, volume of vegetative material, and possibly with depth and volume of plant roots, it seems reasonable that estimation of E_T by formula for forest land may have to be increased by a factor based on these changes in vegetative stature. Either average height of the forest or total volume of vegetative material may provide a properly sensitive parameter for correcting estimates of E_T.

With the additional years of record since the last analysis and the proposed reanalysis of E_T, P, and RO relations at Coweeta, there may not exist a better place to put the energy balance concept to the acid test concerning its applicability to all forms of vegetative cover. In addition, there may not be a better framework upon which to hang Coweeta water balance results than a modified energy balance formula.

Quarterly Report, October -December 1956

General

Professor Robert E. Dils returned to the University of Michigan after completing the first draft of a guidebook for Coweeta. David Striffler returned to the same school after completing the field work on a soil moisture problem as a partial requirement for a Master's thesis.

Studies

Clearing work has been completed on Watershed No. 1 where eventually a south-facing watershed planted to white pine will be compared to a north-facing watershed (No. 17) which was planted to white pine a year ago. A careful program of slash and brush burning was carried out prior to the felling of the overstory. The entire operation from cruising to completion required about 450 man-days. Water yield data from No. 1 have not been analyzed to date so that no comparison with Watershed No. 17 is available.

Collection of data on a soil-moisture-elevation study at Coweeta has been completed by David Striffler who is now doing the analysis work at the University of Michigan. Soil moisture samples will be continued to be collected to assist in determining the changes in soil moisture storage in the water balance equation.

Other studies are in progress on soil moisture, interception, adequacy of the Coweeta precipitation network, and integrated land use studies.

Hydrologic Notes

Climatic summary of air temperatures and evaporation are as follows:

Month	Temperature						Evaporation	
	Average		Maximum		Minimum		1956	Dev. from normal
	1956	Dev. from normal	1956	Dev. from normal	1956	Dev. from normal		
Oct.	57.7	+ 1.7	70.4	-0.5	44.9	+ 3.7	2.10	- 0.47
Nov.	44.8	- 0.3	59.1	+0.5	30.4	- 1.0	1.92	+ 0.23
Dec.	47.3	+ 7.8	59.1	+7.8	35.5	+11.2	1.20	+ 0.15
Aver.	50.0	+ 3.1	62.9	+2.6	37.0	+ 4.6	1.74	- 0.03

Summary of precipitation for the quarter is as follows:

Month	Total	Deviation from normal
October	5.16	+ 1.70
November	2.34	- 2.81
December	8.70	+ 1.57
Total	16.20	+ 0.46
Water Year to 12/31	11.04	- 1.24
Calendar Year to 12/31	71.24	+ 1.86

Cooperation

Region 7.--Whelan and Shope spent Dec. 3 and 4, 1956, reviewing in the field and the office the pilot study on logging and roads on Black Run Watershed being conducted by the George Washington National Forest and the Coweeta Hydrologic Laboratory. Whelan investigated a rehabilitation problem on a strip-mining operation and a flood problem on the Federal Prison Camp on the Monongahela National Forest.

Region 8.--Whelan discussed the new method of rating the forest hydrologic conditions on Nov. 5 and 6, 1956, with Clapp, Spector, and Friedrich. Hewlett and Shope on November 29, 1956, looked over the Stamp Creek timber sale on the Chattahoochee National Forest, another pilot plant study. Work is progressing well on this sale. The watershed damages are being held to a minimum and the logger is reported to be well satisfied with his logging chance.

Southern Station.--Whelan participated in a conference at New Orleans, La., on November 27 and 28, 1956, to consider the advisability of including a rating of the forest hydrologic condition in forthcoming Forest Survey in Arkansas.

ASAE Meeting.--Whelan attended the winter meeting of the American Society of Agricultural Engineers in Chicago, Ill., on December 9-12, 1956. A feature of the meeting was a presentation of a compilation on current research on "Evaporation and Evapo-transpiration in the United States and other countries." Copies of this compilation can be secured from the ASAE executive office in St. Joseph, Mich., for $1.00 each.

Visitors

One hundred and thirty-two visitors kept the staff busy during this quarter. The Wayah and Highland Ranger Districts held their fire-training school on Watershed No. 1 of Coweeta where they could practice fire control during our burning operations. Our total number of visitors for the year was 554, a below average figure due to the relocation and rebuilding of U.S. Highway No. 441 and 23. We were privileged to escort around the Coweeta area Mr. J. C. Wilson, Senior Asst. Conservator of the African Gold Coast, and Mr. Osvaldo, Assistant Chief Forester of Chile.

New Soil Moisture Study

A study of the effect of cutting Piedmont stands on soil moisture was initiated during March. The study is one of a planned series of observations of soil moisture, utilizing existing timber sale areas as experimental areas. These observations will give a rough measure of water use of some representative Piedmont stands. As such, these studies constitute one phase of an important field of work in the Piedmont - that of defining and evaluating the timber-soil-site factors affecting water yields from small watersheds.

The present study involves a loblolly pine plantation thinned to two levels of basal area. A primary aim of the study is to determine moisture depletion rates for the thinned and unthinned stands by depth zones during the growing season. A related aim is to determine the effect of thinning on the capacity of the soil to store winter precipitation. It should also be possible to relate degree of thinning to soil moisture recharge following rains.

It has been found in the Piedmont that water loss occurs throughout the surface six feet of soil. The magnitude of the water loss below six feet, if any, is not known. The present study is designed to follow soil moisture trends to eight feet and thereby increase available information on soil moisture characteristics on the surface few feet of soil.

Gravimetric samples of each six inches of soil will be taken twice weekly and after rains to a depth of 48 inches and biweekly to a depth of 96 inches.

Soil Moisture Publication

A publication of five years of soil moisture observations of barren, grass covered, and typical timbered areas is in the final stages of preparation and should be in the hands of the reviewers shortly. Soil moisture observations were made utilizing Colman fiberglas units.

Life in the Soil

"Deer, jumping mice, and the oven-bird are denizens of the forest floor by virtue of using it as their substratum, but there is also a host of curious animals which use the forest floor, especially the litter of dead leaves, twigs, branches, and fruit parts, as their walls, ceiling, and sub-basements. Looked at from the eye-level of the cockroach, this litter becomes a several-story edifice of enormous extent. The various floors are separated by twigs, midribs, petioles, fruit husks, samaras, skulls, elytra and faeces. The lower one descends, the more compact is the structure. The leaves become more fragmentary, the faeces of worms which have come up from the soil, of caterpillars which live in the trees and of the inhabitants themselves, as well as grains of sand brought up by the worms and a heterogeneous

assortment of beetle skulls and wing covers, become more abundant. This complex is rendered more intricate by the growth of minute fungus moulds which feed upon the dead leaves and organic refuse, weaving it all into a compact mat by their myriad white hyphae. Thus is the woven into the warp of the woodland rug." Thus, in the words of A. P. Jacot, is a picture of the teeming life which exists in the forest floor.

The field of soil fauna has generally been relegated to the nomans-land between the interests of the zoologist, entomologist, and soils worker. As a result, most of the work done in the past has to be dug from obscure (at least to a forester) journals and textbooks which cover only small segments of the field.

Recently there was published in England a book which will be of value to all those interested in soil fauna. (Kevan, D. K. McE, Editor, Soil Zoology: Proceedings of the University of Nottingham, Second Easter School in Agricultural Science, 1955, Academic Press, New York, 512pp., $10). As the title indicates, this book is not a text, but rather a selection of papers.

The book is divided into two parts, the first being concerned with general papers on soil fauna, pedology, ecology, and applied aspects. These papers range from such things as the identification of terrestrial mites to earthworms ecology. The second part of the book concerns methods. This is divided into sections covering sampling procedures (arthropods, worms, nematodes), cultural methods, preparations (preserving and soil sectioning), and physiology.

At the end of each paper there is a summary of the floor discussion which followed the presentation. Two of the most valuable aspects of the book are the bibliographies and the identification keys. The last 36 pages of the book are devoted to "A practical key to the orders and suborders of soil and litter inhabiting animals."

This is certainly not the type of book that need be found on the reference shelf of every forester. However, for anyone interested in soil biology it should prove stimulating and worthy of study.

Quarterly Report, October - December 1956

Climatic Summary

The year 1956 ended with a rainfall deficit of 5.91 inches. October, November, and December were all deficient in rainfall.

Quarterly Climatic Summary - Calhoun Experimental Forest

Month	Average temperatures: Max.	Min.	Mean	Highest temp.	Lowest temp.	No. of days with rain	Precip.	Evap.
	°F	°F	°F	°F	°F		Inches	Inches
October	71	52	62	87	36	11	2.53	2.70
November	63	34	48	82	14	6	1.03	1.96
December	64	40	52	77	19	6	2.47	1.70

Effect of Fire on Soil

One of the soil properties most likely to be affected by fire is the infiltration rate. This rate can be measured a number of ways, both in the field and in the laboratory. In order to test one of the laboratory methods under relatively controlled conditions, the following study observations were made.

On a very limited area, so that soil properties were homogeneous as possible, 30 undisturbed volume samples were collected. These were taken from two sites, one with a clay surface soil and one with a sandy surface soil. Surface organic layers were removed so that the top of the sample consisted of mineral matter. All samples were sealed with wax around the edges to help prevent leakage between the soil and the metal cylinder. Half of each textural series samples were given several consecutive percolation runs so that the normal change (a slight decrease in this case) could be noted. The other half of the samples were run and then treated and re-run. Treatment consisted of the addition of pine litter ash to the surface of the sample at the rate of 16,000 pounds of oven dry litter per acre.

The second percolation run, with the ash on the surface, was less than the first, even when the normal decrease was taken into account. The decrease in rate, due to the ash, was 0.3 inch per hour for the sand (runs ranged from 2.5 to 8 inches per hour). The differences due to ash were not significant.

It is possible that different results would be obtained if charred material, as well as ash, were applied to the sample. This line of attack may be followed in future studies.

Discussion

On page 5 of the Northeastern Station write-up in the April-September 1956 Semiannual Report of the Watershed Management Research Division a question is posed concerning separation of hard soil and soft rocks. They do not state whether they propose to use the soil for subsequent analyses after rock is removed.

The force that is applied to the soil must be constant for all samples and therefore "easy rubbing with a brush" and such systems are not too good. If they want to keep the soil dry, one good approach might be the use of a sieve shaking machine.

Assuming the sample must not be reused then it appears to me the problem is one of pretreatment. We don't have the soft stone but have worked with hard soils. I would try the following procedures:

(1) Soak sample in water for three or four days.

(2) Soak sample and then boil for half hour or so.

(3) Soak sample and add some sort of a dispersing agent as used in textural analysis.

We have never had to go to these extremes on our soils, but they might help.

SEMI-ANNUAL REPORT
Division of Watershed Management Research
Southern Forest Experiment Station

October 1956 - March 1957

General

Highlight of the six-months period was a meeting held in New Orleans on November 27-28, 1956, to discuss the use of the new Forest Survey in Arkansas as a means of obtaining watershed information. In attendance were: H. F. Morey, W.O.; H. G. Meginnis, and Don Whelan, SE Station; Al Spector and C. A. Friedrich of R-8; and P. R. Wheeler, R. S. Campbell, H. D. Burke, G. M. Judson, J. R. Bassett, T. E. Avery, James Smith, and S. J. Ursic, Southern Station. Limited distribution was made of the dittoed Minutes, which included the November 13, 1956 revision of a statement by Morey and Whelan on "Estimating Runoff Curve Numbers for Forest and Woodland Areas."

It was decided that the first followup item is the matter of defining forest floor and soil criteria more clearly, as a code sheet. Review draft of such a dittoed code sheet was prepared by Spector and Judson and distributed on February 28, 1957.

Morey agreed to discuss with the SCS in Washington the practicability of tying in the hydrologic soil grouping with a productivity grouping, as Forest Survey is particularly interested in site productivity.

It was decided to collect Forest Survey data by coded watershed units corresponding to the FIARBC River Basin Maps folio, in addition to regular Survey units.

It was the consensus of the meeting that the Southern Station's plan to establish "diagnostic" Forest Survey plots should lend itself to greatly extending the information in flood prevention and related activities.

A second meeting, to work out tentative field procedures, is planned in May 1957. The Central States Station has requested representation at this meeting, to consider possible application of the methodology to the Forest Survey being planned for Missouri.

The minutes of the Eighth Meeting of the Arkansas-White-Red Basins Inter-Agency Committee (Nov. 14-15, 1956), in Appendices D, E, F, and G, contain excellent summaries of water pollution problems in Arkansas, Louisiana, Oklahoma, and Texas.

The Southern Station was well represented at the annual SAF Meeting in Memphis in October 1956.

The Arkansas Water Study Commission, appointed by the Governor, is working on State water use legislation pertaining to four major fields: agriculture, industry, municipal, and recreation. A Pilot Bill, introduced in the 1955 Session of the Legislature, failed to be enacted, but a new bill is planned for the 1957 Session.

The Vicksburg Infiltration Project has called attention to a little known report on securing, preserving, and handling of undisturbed soil samples. The citation is: Hvorslev, Juul M. Subsurface exploration and sampling of soils for civil engineering purposes. Report on a research project of the Am. Soc. Civil Eng., sponsored by the Engineering Foundation, Harvard University, and the Waterways Experiment Station, Nov. 1948, 465 pp. (processed). It may be obtained through The Engineering Foundation, 29 West 39th Street, New York 18, N. Y. Price $6.00.

Personnel

Hubert D. Burke transferred from the Division of Range and Watershed Management Research in New Orleans to take charge of the Vicksburg Infiltration Project in January 1957.

Publications

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VIP Staff. Forecasting Trafficability of Soils. Information for Predicting Moisture in the Surface Foot of Various Soils. Report No. 4, Technical Memorandum 3-331. Feb. 1957.

Manuscripts in Preparation or Being Edited

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Carlson, Charles A. Estimation of the Field Maximum Moisture Content. Presented at SSSA Meeting, Cincinnati, O., Nov. 1956. Submitted for publication in Proceedings.

Eschner, A. R., B. O. Jones, and R. C. Moyle. Physical Properties of 134 Soils in Six Northeastern States. Northeastern Forest Experiment Station.

McClurkin, D. C. Maleic Hydrazide Fails to Control Fertilized Bermudagrass. Submitted to Agronomy Journal March 1, 1957.

_____ Soil Moisture Content and Shortleaf Pine Radial Growth in North Mississippi. To be submitted to Forest Science.

Thames, J. L., and S. J. Ursic. Improved Rain Gage Supports. To be submitted to Journal of Soil and Water Conservation.

VIP Staff. Forecasting Trafficability of Soils. Prediction of Soil-Moisture Content at Sites Without Detailed Records. Report No. 5, Technical Memorandum 3-331. Being processed.

Tallahatchie Research Center

General

McClurkin attended the ASA meeting in Cincinnati in November. Thames visited Coweeta for two days in December.

Nine foreign visitors spent several days to several weeks at the Center. Countries represented included India, Korea, Turkey, Bolivia, Chile, and Yugoslavia.

North Mississippi again was plagued in 1956 with a dry summer which caused generally poor survival on the tree planting studies. June through September had 5.17 inches of precipitation (normal 15.53 inches), with respective monthly deficits of 1.89, 3.74, 1.51, and 3.22 inches. The drought did serve a purpose, however, in that it provided a critical test for several of the studies. The rains finally came, with 13 inches in January 1957, hampering construction of the second battery of small watershed installations.

Heavy tip moth infestation of plantings on critical sites led to control attempts, several of which appear promising. A high in the rabbit population cycle also added headaches and resulted in considerable dashing around replanting on plots where seedlings were seriously damaged.

Watershed Studies.--Construction of the first three small watershed installations was completed in December and operations started as of January 1, 1957. These 2- to 3-acre drainage areas are actively eroding, abandoned old fields typical of much of the idle land in need of reforestation in

north Mississippi and environs. The units are constructed with concrete approach sections and equipped with H-type flumes. The Coshocton fractional wheel samplers were installed and in operation by March 1.

Thirteen inches of rain in January carried off much of the soil around the approach sections that had been disturbed during construction.

So far only occasional difficulty has been experienced with silting-in of the well inlet, and then only during the first few storms when large quantities of material (up to 35 cubic feet) were deposited in the approach section and flume. This is mentioned because silting-in of the well inlet is one of the major objections to using the H-type flumes.

Despite the small size of the areas and similarity of soils, differences in the flow characteristics of the three drainage units already are apparent. While peak flows and the hydrographs are similar, the delayed flow on one of the units is sustained for several days. This is probably due to a pronounced development of a platy plow pan at about six inches, in addition to a fragi-pan at about 24 inches, over most of this drainage.

The initial tier of electrical soil moisture units will be installed in March. After the soils have been mapped in more detail, the problem will be to determine the extent and frequency of gravimetric sampling required to give, within acceptable limits, estimates of soil moisture conditions over the drainage units. This is one of the phases of soil moisture measurements which is relatively unexplored.

The fractional wheel samplers are operating well. Without diverting low flows the sampler activates at a stage of 0.10 feet (0.0347 cfs). Hand sampling of low flows indicates that the runoff at stages below a 0.10 foot stage, especially on the recession side of the hydrograph, is relatively free of sediment, but further observations are needed.

Construction of the second battery of three drainage units with depleted upland hardwood cover was scheduled to start in December, but continuous wet weather hampered progress.

Planting Studies

Degree of Root Pruning.--A study to compare early survival and height growth of loblolly pine seedlings pruned to four different root lengths, and unpruned seedlings planted by two methods, was established in February 1956. The seedlings were outplanted in three blocks on actively eroding, droughty sands. After one growing season survival averaged 35 percent, with no significant differences in either first-year survival or height growth due to degree of root pruning, or to method of planting unpruned seedlings.

The study was reinstalled in February 1957. Three blocks were established on droughty sands, and three blocks on sparsely vegetated and compacted loess soils.

Mulch Requirements for Pine Establishment.--First-year measurements of a study to compare the effects of mulch (wild hay and grain straw) on initial survival and early development of loblolly pine planted on three adverse site conditions were made in October 1956. Mulch as applied in this study had no significant effect on either height growth or survival after one growing season. Unexpectedly, survival was highly significantly better (78 percent) on the rock-like Coastal Plain parent material than on either the droughty sands (42 percent) or the eroded loess sites (40 percent). Although differences were small, first-year height growth was best on the loess sites, and as could be expected, poorest on the Coastal Plain material. It remains to be seen if seedlings on this difficult site will develop sufficiently to provide adequate cover for site protection.

Broadcasting mulch at the rate of one ton per acre cannot be recommended because of the poor coverage obtained.

The study was reinstalled in February 1957. Pine litter was used in addition to the wild hay.

Time of Root Pruning Loblolly Seedbeds.--A study to compare survival and early development of loblolly seedlings root-pruned in the nursery beds at various intervals of time prior to lifting was installed in February 1957. Seedlings were outplanted in three randomized blocks on each of three site (soil) conditions. Mid-summer survival will be checked in June, and first-year survival and height-growth measurements will be made in October.

Morphological Grades of Loblolly Pine.--First-year measurements of a study to compare survival and early development of three morphological grades of loblolly pine seedlings planted on eroding, droughty sands were made in October 1956. The dry summer provided a severe test. Both survival and growth indicated the desirability of planting the better morphological grades.

The study was reinstalled in February 1957. Three blocks were established on deep sands and three blocks on the better old field sites with loess soils.

Effect of Temperature on Loblolly Pine Seedlings.--A study to determine lethal temperatures for loblolly pine seedlings was installed in February 1957. Seedling roots were immersed in water baths at various temperatures for two hours. An additional lot was frozen and slowly thawed. The seedlings were outplanted in four blocks on a loessial soil. Survival will be checked monthly. Height growth will be measured in October. After one month the apparent vigor of the seedlings was still good despite initial bath temperatures up to 160° F.

Depth of Planting and Pre-Planting Treatment.--A study to compare the effects of shallow, and two degrees of deep planting; and pre-planting treatments (watersoak and puddling), on the early performance of loblolly pine was installed in February 1957. Seedlings were outplanted in four blocks on each of two old-field sites--droughty sands and loessial soils.

Pine Species Adaptability on Adverse Sites.--Virginia pine, sand pine, and races of loblolly and shortleaf pines which have demonstrated drought resistance in other areas are being tested on adverse sites in the Tallahatchie area. Seed for each of the species and races was collected and planted in the nursery in 1956. Despite heavy initial losses of seedlings attributed to damping off, enough survived to plant 400 each of eight different species and races in February 1957.

Soil Collection Trenches Use in Revegetating Eroded Land.--This study will determine the effect upon survival and growth of loblolly pine seedlings planted on adverse gully sites. Seedlings were planted in February 1957 in trenches which have been allowed to fill with alluvium.

Post Hole Plantings as an Aid in Revegetating Eroded Lands.--A study to determine the effect of six methods of site preparation upon survival and growth of loblolly pine seedlings planted on eroded, exposed Coastal Plain subsoils was installed in February 1956. Four of the methods are designed to test the effect of planting seedlings in topsoil-filled auger holes 24 inches deep in combination with various mulching and fertilizer treatments. The other two methods are designed as controls. They are mattock planting-no treatment and mattock planting-mulched. First-year survival was excellent on all plots and no significant differences due to treatment were indicated.

Use of Balled 1-1 Stock in Revegetating Adverse Sites.--This study was designed to supplement the post hole planting study by planting seedlings in post holes back filled with removed soil. Other treatments added were planting 1-1 balled stock (lifted from an adjacent field) in auger holes filled with topsoil and in holes filled with removed soil. Control plots were mattock planted. The study was installed in February 1957.

Pine Response to Fertilizer.--A study to determine the effects of single and repeated fertilizer applications on survival and growth of loblolly pine seedlings planted on severely sheet eroded sites was reestablished in April 1955. Half of each plot received a second fertilizer application prior to the 1956 growing season. Fall measurements indicated no significant differences in survival or height growth due to treatment or to number of fertilizer applications.

Soils and Soil Moisture Studies

Grasses and Legumes for Erosion Control.--A study to determine the effects of selected grasses and legumes on soil hydrologic properties was established in January 1955. Plantings were reinforced in the fall of 1955 and spring of 1956. Fertilizer was broadcast periodically during the growing season. Plots were remeasured during the winter of 1956-57, and soil samples were taken to determine the effect of the plantings on the site. Weeping lovegrass (Eragrostis curvula) was consistently successful in germination and survival. Laboratory determinations indicate only slight improvement in bulk density and percolation rates so far.

Soil Moisture and Tree Growth.--A cooperative study was installed in April 1954 to determine the relationships between tree growth and soil moisture content as they vary with time; also to obtain soil and soil moisture data for the Vicksburg Infiltration Project. The study is now closed, and the manuscript describing results is being edited.

Site Changes with Species Conversion.--A study was installed in March 1954 to determine the nature, rate, and extent of site changes associated with conversion of ridge stands of worthless hardwoods to pine. Survival and growth of the planted pines continues to be excellent.

Soil Moisture Variations with Ridge Conversion.--This study is designed to determine the variations in soil moisture content on blackjack-post oak ridges when the ridges are converted to pine with different intensities of hardwood removal. Results of one year of weekly moisture sampling indicate the greatest water loss was on plots where the hardwood understory was eliminated. Smallest losses occurred on plots from which both hardwood overstory and understory had been removed. Intermediate water losses were on plots on which the overstory only was killed.

Moisture and Growth Changes with Thinning.--This study is designed to determine the changes in soil moisture content and tree radial growth associated with plantation thinning. Two of three blocks were thinned to a basal area of approximately 80 square feet while the third was retained as a control. At the end of one year's measurements, there is no response to thinning.

Vicksburg Infiltration Project

From its beginning in 1950 until 1956, the Vicksburg Infiltration Project operated on an annual basis. After the Consultants' Meeting, July 31 - August 1, 1956, plans were made to complete the reports on the development phases of the soil-moisture prediction work and to begin the task of refining and applying the method to a variety of soil and climatic conditions.

Because of the complexity of various problems which had been experienced in the development of the prediction method, it was decided that the year-to-year basis of operation was impractical. Accordingly, plans are for the Vicksburg Infiltration Project to continue 4 or 5 years in order to allow sufficient time for study of these more difficult problems. The Project will continue to function as a Research Center of the Southern Station.

The new work is proceeding slowly in order to make a critical survey of the hydrological requirements for trafficability forecasting, and because time is needed for the completion of reports on the past developmental phases of the work. Report No. 4, "Information for predicting moisture in the surface foot of various soils," was published in February 1957. Report No. 5, "Development and testing of a set of tentative standard relations for application to soil moisture prediction," is being edited and a rather voluminous Appendix is being assembled and made ready for printing. The Puerto Rico report is being deferred until Report No. 5 has gone to press.

The limited technical staff is a considerable barrier to rapid progress. In 1956, under the assumption that the Project would soon close, many of the staff transferred to other Research Centers. Jerry Horton returned from the Rocky Mountain Station during October to write the first draft of Report No. 5. The technical staff now consists of Burke, Carlson, who transferred to the Army Engineers in May of 1956, but who remains with the Project through cooperation with the Waterways Experiment Station, Robert Tobiaski, and Edmond Swensen.

Limited field work was started in November at eight sites established by the Geology Branch of the Waterways Experiment Station. These sites are being used for three exploratory type studies. The first is an attempt to obtain a correlation between strength measurements, using a cone penetrometer and remolding measurements, with soil moisture under very wet soil condition. A second exploratory study on the same sites is an attempt to correlate water table height with moisture in the surface to 12-inch depth of soil. Some work was done at a similar site in 1951-52 and it is hoped that the added information gained in this exploratory study will assist in preparing a definitive working plan for a study of high water table soils. These eight sites are also being used to apply and test the "Tentative Standard Prediction Relations" on alluvial soils. Precipitation and soil moisture measurements are being made.

A detailed study program is being developed and a prospectus for each of the planned studies is being prepared. Rate of progress at least for the immediate future will largely depend upon our ability to recruit additional research personnel.

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Division of Watershed Management Research
April-September 1957

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